Battery Metals

23 June 2023

Mining

Global Vehicle Sales – Unstoppable EV Hybridisation

Summary

- **Global 2023 EV production 65-70% Chinese origin**
- **US EV market is half that of Europe**
- **Hybrids to dominate future EV transactions**
- **Forecast >12m EVs to be sold in 2023**
- **>26% of all vehicle sales (China, US, EU) to be an EV**
- **Strong future lithium & REE demand**

We are updating our vehicle/EV sales, and general vehicular trends. These sales numbers, together with the breakdown of various segments from Europe, the United States and China, form the basis of our growth projections. From that, we derive future demand profiles for lithium and REEs. In each commodity, we have created a regression model, allocating different abundances utilised in each vehicular segment, before applying our vehicle overlay to derive final demand numbers.

Global vehicle sales are down >30% from their 2017 peak, with current conditions remaining depressed. The reasons behind this trend are varied, ranging from (i) car price cost inflation outpacing incomes, incentivising consumers to retain existing stock; (ii) significant cost of pure battery electrical vehicles (BEVs) going forward, which we believe will remain structurally higher than current internal combustion engines (ICEs); (iii) the trend of younger generations to eschew traditional vehicular ownership, and adopt micromobility measures and auto App platforms (*e.g*. Uber and eScooters).

What is evident, is that the vehicle market is in the midst of a transformation, buffeted by different governmental policies, technological changes and evolving consumer expectations. Our contention remains that Western BEV producers (with the exception of TSLA), will exit the industry as legacy manufacturers continue to dominate sales, transitioning toward hybrids. China will increasingly dominate the global vehicle market and will become the world's largest vehicle BEV and ICE exporter by year's end.

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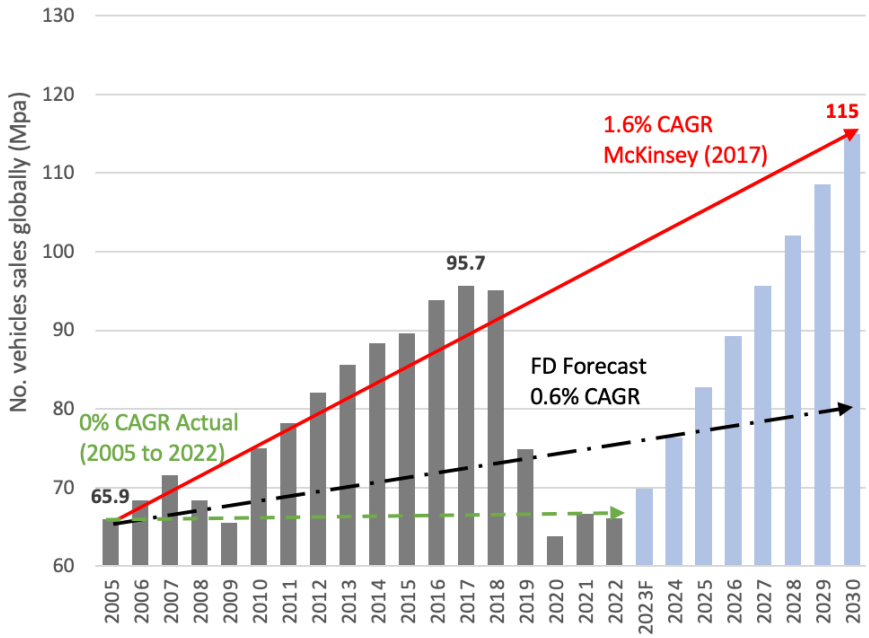
Global Vehicle Sales

Before the nascent arrival of the EV sector, little more than a decade ago, the prevalent fear by many mineral economists was the lack of hydrocarbons and materials needed to supply two large emerging markets, namely, China and India. It was a view that formed the sustained growth model (at that time) in vehicle sales (see Figure 1). Unsurprisingly, as in life, what actually occurred was something entirely different. Global vehicle sales peaked in 2017 and have since declined. The main reasons why this occurred synchronously, are irrespective of economic development (see Appendices A, B, C & D), and the fact that it occurred before the advent of the EV transition, meaning it cannot be attributed to a single event. We cover regional EV sales in China, Europe and the United States; discuss political implications associated with the modification of the ICE ban in Europe; micromobility issues; and the emergence of China not only as the world's largest car manufacturer, battery supplier and EV producer, but also has just become the largest seaborne vehicle exporter globally.

The global car market is undergoing transformation from vehicle ownership to usage, which requires different business models.

Figure 1: Actual and projected global car sales. Ironically, the McKinsey forecast was considered, at the time, to be conservative.



Source: FD

We have adjusted our forecast global sales for the remainder of the decade, which are >30% less than previous consensus forecasts. These numbers form the numerical basis from which we estimate total EV sales, and type, in each of the three major markets (i.e. the United States, China and Europe); from that point, we are able back-calculate both future lithium and REE demand tonnages.

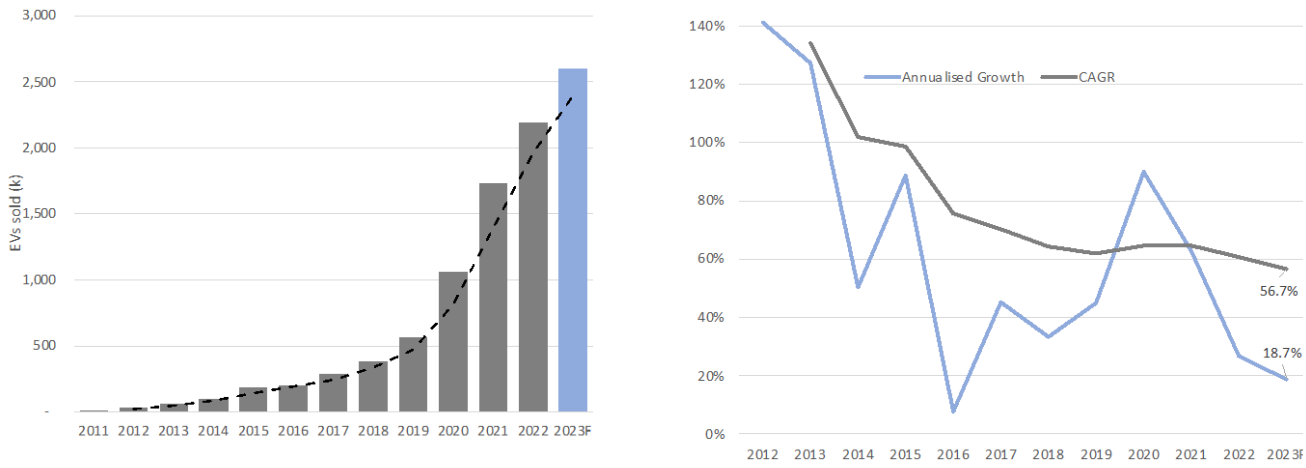
Regional EV Sales

Europe

EU PHEV[1]/BEV sales grew by >26% in 2022 to ~2.2m units; we forecast sales to grow ~19% to above 2.5m units in 2023 (see Figures 2 & 3). The average sales price[2] for a BEV in 2022 was ~€54k, whilst a PHEV averaged ~€60k. Even if we take into account that these types of EVs tend to occupy the prestige end of the market, by comparison, a well-appointed VW Golf ICE vehicle is >40% less, at ~€31.6k (average ICE car is substantially lower again).

The adoption of any new replacement technology is normally more expensive than the current application, but economies of scale and technological adaptation, push these costs downward over time; to the point where the new application ultimately ends up being cheaper that what it replaces. In this instance, however, we contend that the current price differential (between BEVs and ICEs) is unlikely to diminish in time, because the cost disparities encompassing both the energy necessary to acquire the necessary materials, processing and refining, and the manufacturing intensity to build the unit[3]. This cost discrepancy between BEVs and their ICE equivalents, coupled with inherent operational restrictions, has led us to question the narrative surrounding total BEV adoption.

Figures 2 & 3: Number of newly registered EVs in Europe from 2011 to 2023F, with Germany alone accounting for approximately a third (left); and comparing annual versus CAGR growth rates over that same period (right).



Source: FD

[1] Plug-in Hybrid EV

[2] https://www.statista.com/outlook/mmo/electric-vehicles/europe#revenue

[3] Li-ion battery modules have significantly higher carbon footprints, contributing collectively ~30% to the total footprint of all materials and components in the C40 Recharge model. Greenhouse gas emission break-even analysis using different electricity mixes suggest that it would take a typical BEV driver 110,000km to reach CO_2 emission parity with its petrol-powered equivalent (using a global electricity mix – but is significantly less if you use an EU generation amalgam). https://www.volvocars.com/images/v/-/media/market-assets/intl/applications/dotcom/pdf/c40/volvo-c40-recharge-lca-report.pdf

Which raises an interesting quandary, if the cost differential between an ICE and BEV is structural, the implication being that over time, given mechanical obsolescence, an increasingly large portion of the public may not be able to either, afford[4] the purchase of vehicles, and/or acquire vehicles able to fulfill operational requirements, and even more importantly, what are the political ramifications of such an eventuality? It is this political consideration which we believe was partly behind the dropping of a blanket ban on ICEs by the EU; the ramifications of which, we will discuss in greater detail (see page 10 onward). Hence, contend that hybrid sales are a realistic compromise that straddle most aims and their ability to deliver cost effectively; and forecast they will increasingly dominate EV sales.

China

China accounted for almost 60% of global EV sales in 2022, with CAAM[5] sales figures showing 444k BEVs were sold in the month of April, making up 25% of the entire Chinese auto market. According to the IEA (2022)[6] China also accounts for 95% of global registrations of electric two-and three-wheeler vehicles, which account for half of its EV domestic sales; as well as, 90% of world electric bus and truck registrations.

Figures 4 & 5: Hongguang Mini EV starts at $4,300, has been the best-selling micromini for the past two years.

Source: InsideEV (2022)

We acknowledge that it is disingenuous of us to compare disparate markets without recognising unique features distinctive between them. For example, the sales-weighted average cost of a BEV in China[7] in 2021 was ~US$27k, compared with ~$58k in Europe. Why the difference? There are greater than 450 registered EV firms[8], most of whom specialise in producing small EVs. Much like the Kei car category in Japan, these models differ significantly in size, range, features and structural integrity, are unlikely to be appealing or meet, Western safety standards, and for the purpose of commodity forecasting, unlikely to be sold in any significant numbers outside its domestic market. The Hongguang Mini (see Figures 4 & 5), for example, has been the best-selling EV for several years in China, has an official range of 120km (~75-80km real world), weighting 665kg, its electric motor providing 15kW and 85nm of torque powering the rear wheels; powered by a 9.2kWh battery, prices start at US$4,300 or £3,600 per unit. By comparison, the cheapest EV sold in the UK is the MG4 (Chinese owned), starting at £26,650 per unit, weighing 1,660kg, powered by 50kWh battery, and has an official range of 350km.

[4] The prevalent argument is that additional purchase cost is offset by life-time operational savings. It has been calculated that running a BEV in Europe saves on average €628 pa; on that basis, given the price differential, it would take, however, the average BEV owner >35 years to make up the difference in purchase price over its ICE equivalent. Since these numbers were calculated, power cost increases have largely negated these savings. https://www.weforum.org/agenda/2023/02/electric-vehicles-cheaper-than-petrol-europe/

[5] China Association of Automobile Manufacturers.

[6] https://iea.blob.core.windows.net/assets/ad8fb04c-4f75-42fc-973a-6e54c8a4449a/GlobalElectricVehicleOutlook2022.pdf

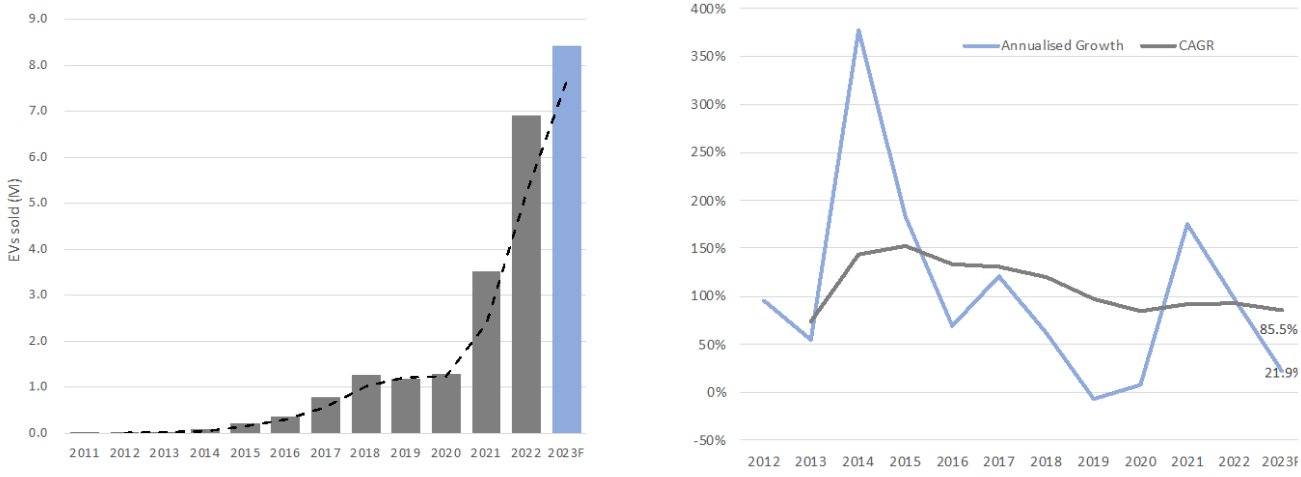
[7] https://www.iea.org/reports/global-ev-outlook-2022/trends-in-electric-light-duty-vehicles

[8] Although 47-48% of sales are dominated by the top four - BYD (28%), SGMW (10%), Chery (5%) and GAC (4%).

Complicating things further, trying to predict future Chinese automotive sales, is to recognise that it is not, and will probably never be, a free market. Its size and composition is strongly dictated by government interaction. Applying generic growth projections based on generalised economic appreciation carries, therefore, a very strong health warning. For instance, to restrain the rapid growth of vehicle ownership, the Beijing municipal government introduced a vehicle quota system[9] in 2011, widely known as the "*license plate lottery policy*". It effectively caps the total number of new licenses issued each month, in addition, it later started to incorporate EV quotas. In 2023, Beijing's quota totalled 100k units, of which, 70% were EV licences only[10]. This programme has been expanded to other mega cities, including Shanghai, Guiyang, Guangzhou-Tianhe, Hangzhou and Shenzhen.

Why is this discussion important? The quantity and type of EV unit sold within and outside China varies significantly if one wants to estimate future lithium consumption and other associated commodities (*e.g.* REES), then regional disparities need to be incorporated into the underlying model as well.

Figures 6 & 7: Number of newly registered EVs in China from 2011 to 2023F (left); and comparing annual versus CAGR growth rates over that same period (right).



Source: FD

In recent years, there has also been a rapid uptake in the sale of hybrid vehicles in China. From 2018 to 2020, annualised sales averaged ~200k units pa, but with the introduction of a number of PHEV models, they accounted for ~25% (~1.78m) of all EV sales in 2022. The rapid adoption, according to CPCA[11], is due to a number of factors, including a lack of charging infrastructure, especially in rural regions (which is not going to change any

[9] When the lottery first began, ~180k people participated, increasing to 1.34m by the end of 2012, and was ~3.34m by the end of 2019. The expansion of the lottery pool size, together with a decreased cap on the total number of new plates, along with the lottery being conducted less often (moving from monthly to every other month), has meant that the odds of winning dropped from 9.4% (January 2011) to 1.4% (December 2012), and is now down to 0.2% in 2019. The expected waiting time has increased <6 months (2011), to 3-years (2012), to ~40-years (2019) (Quan & Xie, 2022).

[10] As an additional measure to curb air pollution, Beijing also bans a fifth of private fuel cars one day a week based on the final digit of the plate number; providing a secondary impetus for potential customers to choose EVs over ICEs. A measure that appears likely be rolled out to other major metropolitan centres in the near future.

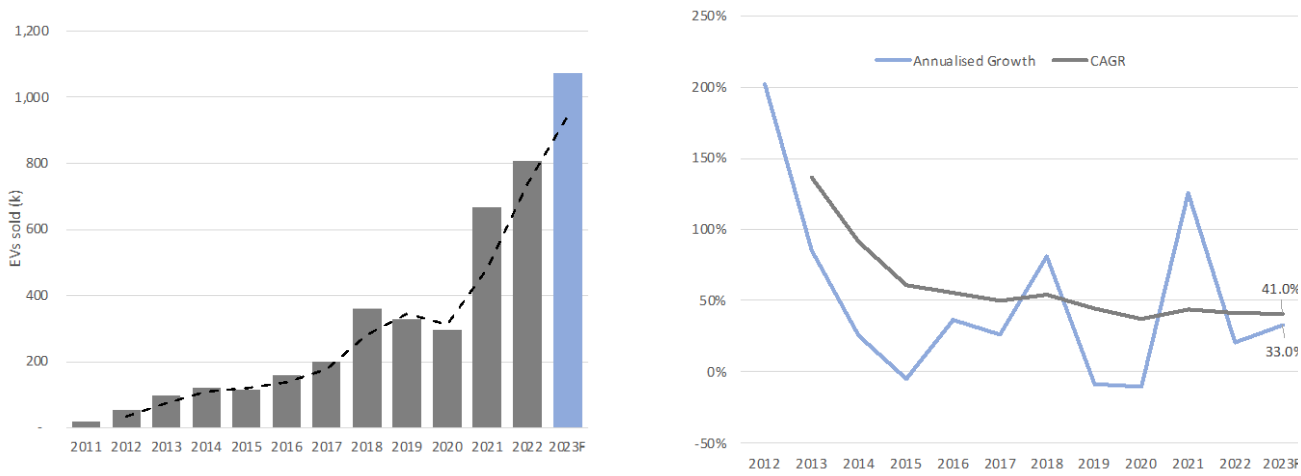
[11] China Passenger Car Association.

time soon), and the range of an average Chinese BEV remains extremely limited (which is also unlikely to change). We contend, however, the real reason is more prosaic, that Chinese PHEVs are significantly more affordable and practical than their BEV counterparts, and importantly, are still allowed to be licensed using an urban EV allocation.

United States

The US has been lauded for overtaking Germany to become the world's second-largest EV market (although still <16% of China). Industry forecasters have predicted that generous US tax credits ($7.5k per unit) could push EV sales toward ~1.6m units this year (although we have been more circumspect in our estimates at ~1.05m vehicles - see Figure 8). But given that these grants are only allocated to U.S.-made cars, it will probably only benefit car makers such Tesla, GM and Ford, at the expense of foreign owned automakers. The net result probably being that overall EV sales increases will be marginal, as a result of direct substitution.

Figures 8 & 9: Number of newly registered EVs in the US from 2011 to 2023F (left); and comparing annual versus CAGR growth rates over that same period (right).



Source: FD

Examining European carsharing data, and the reasons why it has been far more popular per head of population than that observed within the United States; we conclude that the American EV market will not reach EU adoption rates, despite comparable population, income and distribution, because:

i. EU vehicles are typically more expensive to purchase and are substantially smaller;

ii. Fuel prices in the EU are often double that of the US, with toll and congestion charges, and higher governmental taxation regimes, meaning that car ownership is structurally more expensive;

iii. Many European cities were designed and built from the 14th Century onwards, meaning in many instances, permanent car ownership never suited those residing in older urban centres;

iv. Comparative focus by many European governments (nationally and regionally) to establish extensive public transportation infrastructure, in all its guises; and

v. North America has, on average, a lower urbanised density, significantly greater modern town-planning and purpose designed highway infrastructure. Unsurprisingly, this has resulted in a less prevalent and sophisticated public transportation system, which may in the future, may also be a barrier toward other micromobility transportation adoption.

BEV adoption in Europe may always be structurally greater than that in the United States.

Our view remains, that the differences between the two continents (Europe and the United States) is structural, the prevalence of distances travelled, and the lack of public infrastructure, makes BEV adoption more of a challenge for many. Ironically, this is also a period whereby the US consumer is demanding larger vehicles, from having >64% of the entire market[12] prior to 2018, to 78% of all new vehicles registered in the United States in 2022 being crossovers, trucks or SUVs. In 2022, Ford sold >640k F-series trucks; making it America's best-selling truck for 46 consecutive years, and the best-selling vehicle of any type for 41 years. But if one combined truck sales from Chevrolet and GMC, they total ~755k units[13]. Following developments at a number of up-and-coming US heavy-haulage EV providers[14], all are struggling to create a product that meets the requirements of the average American consumer; at a time when the number of passenger cars[15] on the road fell below 100m for the first time since 1978.

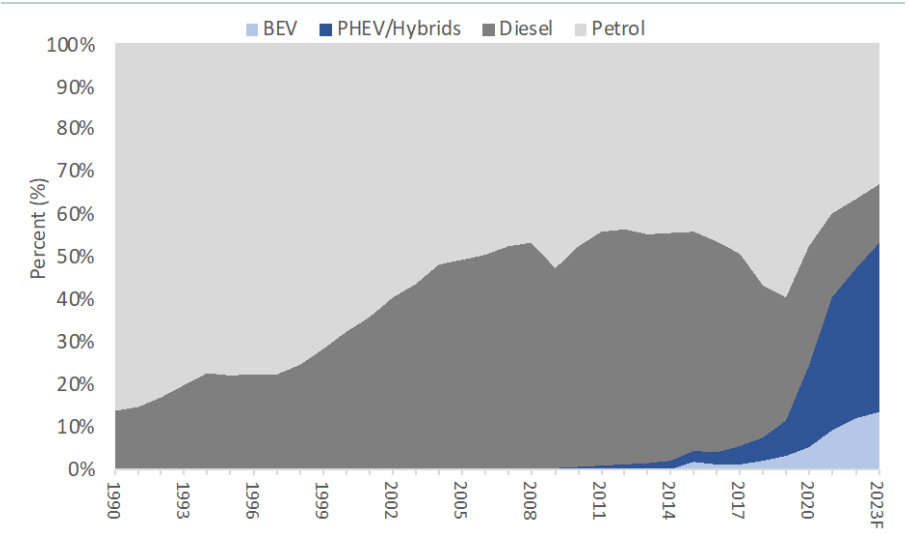
[12] https://www.spglobal.com/mobility/en/research-analysis/average-age-of-light-vehicles-in-the-us-hits-record-high.html
[13] https://tfltruck.com/2023/01/full-size-truck-u-s-sales-report-for-2022-gm-is-still-on-top-ram-slides-down-here-is-what-happened/
[14] For example, Nikola (NKLA: NASDAQ) has the grand intention to deliver a combination of battery-electric semis, whilst developing hydrogen fuel cells. A move into medium distance delivery trucks could theoretically occur if current battery sizes were doubled or trebled, but we have always maintained that NKLA's concept of big rigs able to cover thousands of kilometres, both quickly and efficiently, bounces up against the boundaries of Li-ion chemistry. Which then only leaves hydrogen as the remaining viable option. The problem is that the vast majority (~96%) of hydrogen is manufactured via steam- reforming, using natural gas as its source. The only other commercial process to manufacture hydrogen is by the way of electrolysis, the process by which water is decomposed into oxygen and hydrogen gas (H+ and OH- ions) when an electric current is passed through it; the shortcoming being that you receive substantially less calorific value back than your initial input ranging from 58-75% (*i.e*. energy output divided by energy consumed creating the hydrogen – see Figure 14).
[15] S&P (2022) *Op cit*.

EU's ICE Ban – Now an Aspirational Target?

The EU's public position, until recently, was to implement a ban on sales of all internal combustion engine (ICE) vehicles by 2035; as a key plank toward its 2050 objective of being climate neutral. Normally, approval for this carbon-zero measure would be seen as a *fait accompli*, with this particular proposal due to be voted upon last February. There was, however, always considerable internal unease and disagreement within the Bloc toward this proposal, and it was thrown into disarray when Germany, and Italy, on economic grounds, decided to block it, joining existing opponents, Poland, Bulgaria (it will abstain) and Hungary. When it became increasingly clear to EU technocrats that the ICE ban would not get legislative approval, an 11th hour compromise was made.

This revised proposal now allows ICE vehicles to run e-Fuels[16] (synthetic petrol and diesel) after 2035, an idea championed in particular, by the German automotive industry. On first appearances, it seems to be a modest compromise, and we noted that the announcement did not garner much scrutiny from the financial media. We believe, however, that this change in direction is actually profound, that this new emphasis will result in an entirely different set of consequences.

Figure 10: EU car registration by fuel-type. Forecast BEVs, PHEVs and Hybrids will according to our estimates, collectively, account for ~53% of all vehicle sales in 2023.



Source: FD

[16] E-Fuels use captured CO_2/CO together with hydrogen, the purported benefit being that they release CO_2 into the atmosphere when the fuel is burned, is the same as consumed in the original manufacturing process. Although these fuels are able to be made using renewable power, the process is energy-intensive, with some studies suggesting that e-powered vehicles emit nearly as much greenhouse gases into the atmosphere as a typical ICE, unless offset by direct air capture (DAC) technology (which extracts CO_2 directly from the atmosphere).

What are the Implications?

We speculate that this EV decision is the realisation of *realpolitik*, and is the first step in repositioning previous EU goals, aspirations and ideals, namely:

i. BEVs continue to have operational shortcomings (*e.g.* range, recharge rates, longevity) that are chemistry related, and are unlikely to be mitigated significantly by incremental technological development[18];

ii. BEVs are structurally more expensive to manufacture than ICEs, primarily because of the energy and associated materials[19];

iii. Despite generous incentive schemes, BEV sales data suggests that it is hybrid/PHEV vehicles that the consumer purchases, and it will be they who continue to dominate the EV transition. Hybrids offer economic benefits associated with increased efficiencies, with continued practicality; which speaks to our investment narrative, that if a technology offers more efficient production of superior goods and/or services, then general adoption is rapid; and

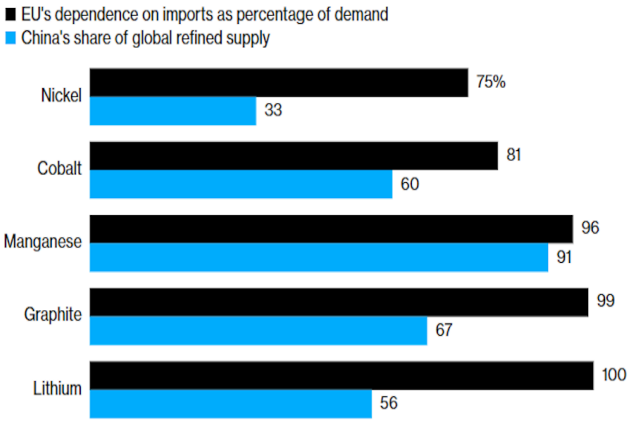
iv. Last, but not least, the decline of global consensus toward economic issues and the rise of Chinese hegemony in minerals processing has meant that potential long-term supplies of various materials and componentry may not be as secure as it has been historically under the continuation of WTO rules. Critical componentry and materials needed for BEV construction could be impinged (see Figure 38), therefore, it's increasingly important to have structural diversity.

Figures 11: Most valuable type of export per country in Europe; dominated by vehicles and machinery. Given Europe suffers from both energy and material deprivation, dramatic reorganisation of manufacturing output is a speculative strategy.

Source: Time (2014), EU (2020)[17]

The reason why so many commodity projects are now being funded by SOEs, is the increasing difficulty in securing debt/equity for mining ventures; in large part, over ESG concerns (which we think are fundamentally misplaced). The Chinese, unencumbered by such niceties are acquiring substantial resources for relatively modest outlays.

Figure 12: The EU's dependency on metal imports is somewhere between 75% and 100% depending on the metal.



Source: Bloomberg (2023); data from EU Critical Raw Materials Report (2023)

[17] https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:52020DC0474

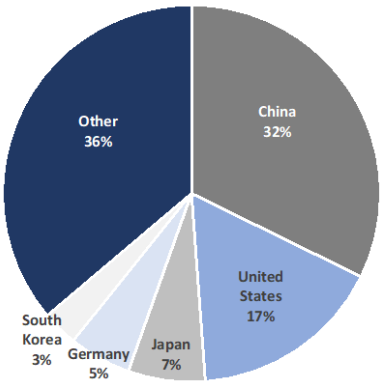
[18] Preface this statement and following assumptions that we are referring to current battery technologies. In their presentation, *Let's change the future of cars*, Toyota claim that their next-generation lithium-ion batteries to be launched in 2026 will have upwards of ~1000km range; while its solid-state batteries, due to be released from 2028 onwards, could extend that by an additional 50% (i.e. ~1,500km).

[19] https://www.mckinsey.com/industries/metals-and-mining/our-insights/the-raw-materials-challenge-how-the-metals-and-mining-sector-will-be-at-the-core-of-enabling-the-energy-transition

The larger discussion revolves around the future direction for the global automotive industry. The European Union has arguably been the driving force behind setting standards and applying soft power in order to illustrate a road-map to the rest of the world toward a decarbonised, more sustainable and circular economy.

A secondary, but equally as important aim was to secure the EU's industrial competitive advantage (see Figure 11), because any proposed EU standards would ensure that Europe remained a technological leader. For this strategy to work, however, it was imperative that everyone would be obligated to follow suit, which has not occurred. Geopolitical tensions emerging following the Ukraine conflict, enforced the latent realisation by the German Government that much of China's economic ascent is based around its reliance on cheap carbon-based energies, providing it with an inbuilt economic advantage. This economic reality has presented an impetus to pause the legislative process.

Figures 13: Manufacturing Output by Country (2021); we estimate that the share of global productive capacity by China is probably >36% currently.



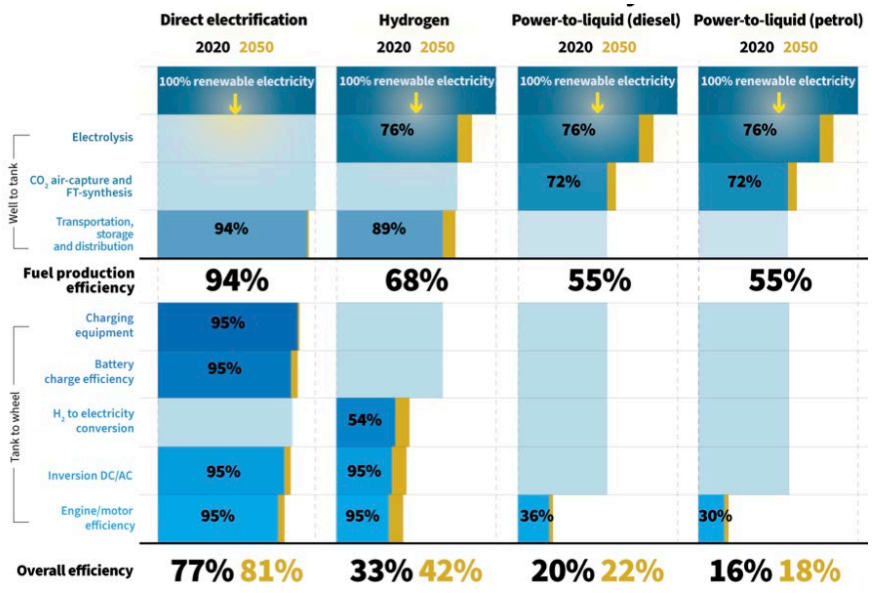
Source: Macrotrends (2023), FD

Potential Sectorial, Political and Business Ramifications?

We would point out that the conditions that have governed international trade since the end of WWII are undergoing a fundamental transformation.

BEVs remain the most efficient form of transport when compared with all other post 2025 alternatives on offer. We question the wisdom of pursuing synthetic fuels as a realistic economic proposition?

Figure 14: Synthetic hydrocarbons[20] come with enormous energy penalties when compared with direct electrification. The 2050 efficiency number is a number of projections assuming various technological advances, which interestingly, if one reads the document, was not applied to ICEs.



Source: transportenvironment (2020). NB - hydrogen includes compression, but excludes mechanical losses.

[20] Prior EU dissention toward this technology (before recent official approval) was based on the premise that promoting even a limited use of synthetic hydrocarbons in road transport (given their very poor calorific recoveries) would lock the EU's transport decarbonisation in a pathway that will require a substantially greater deployment of renewables than otherwise thought necessary. For example, assuming energy source being offshore wind turbines, the required area for power generation would be equivalent to 3.4 (base case) to 5 (higher synthetic hydrocarbon scenario) times the size of Denmark.

Under an emerging mercantilist system, he who controls the resources, controls the means of production. In this respect, it may come as no surprise that of the 34 raw materials that the EU classifies as critical[21], 19 are predominantly imported from China; moreover, for the foreseeable future, this is a situation highly unlikely to change.

i. Synthetic fuels have the ability to be produced from renewable sources (*e.g.* hydrogen or biomass), but are likely to rely on natural gas stocks in the short-to-medium term;

ii. It allows European car makers to switch focus (politically) from BEV products toward hybrids, utilising existing manufacturing facilities, processes and ICE expertise;

iii. Increased consumer flexibility, affordability, potential reversal of the current buyer's strike; and

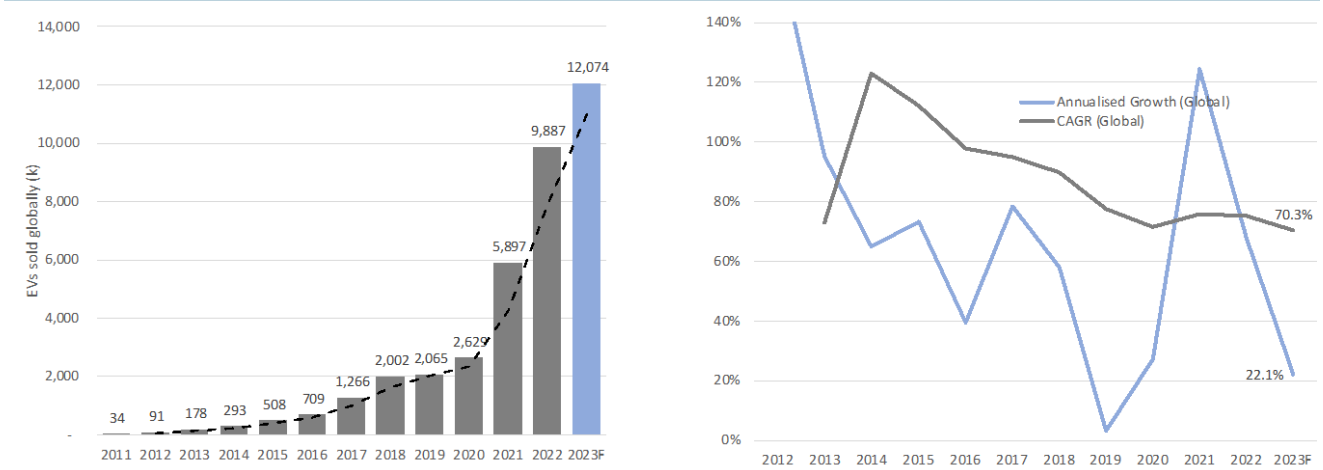
iv. Greater manufacturer competition, increased product diversity should result in greater innovation.

[21] https://single-market-economy.ec.europa.eu/system/files/2023-03/Study%202023%20CRM%20Assessment.pdf

Global EV Sales – The Inexorable Move to Hybrids

We forecast that EV sales for 2023 (for China, the US and Europe) to be ~12m units, up 22% over the pcp. Although a non-consensus conclusion, we maintain that in an increasingly competitive market, legacy manufacturers (*e.g.*, Daimler, Toyota, BMW, VW, GM and Ford) with existing and extensive support network, brand recognition and a loyalty base will put pure BEV car makers out of business (with the probable exception of TSLA). Ongoing cashflows will allow them to invest substantially more (in total, not per unit) in EV research; inevitably this will allow established car makers to pull ahead technologically.

Figures 15 & 16: Newly registered EVs from China, EU & the US from 2011 to 2023F (left); and CAGR growth rates over that same period (right).



Source: FD

Already these legacy names produce EVs that typically match TSLA in range, but are often superior in quality, build, and most critically, price; which led us to a number of conclusions:

i. Given free-cashflow shortcomings of virtually every Western pure BEV manufacturer, implies that if an EV maker that cannot produce or source an ICE to supplement and create a PHEV/hybrid product range, it will struggle to become economically viable in the long-run;

ii. Realisation underpinned our "Short" recommendations more than 12-months ago on a number of EV Makers (*i.e.* LCID, TSLA, EVGO, GOEV, FSR, RIDE, RIVN, WKHS, NKLA);

iii. If BEVs are not the future, then an enormous amount of recharge infrastructure required to be built, but will never be utilised[22]; and

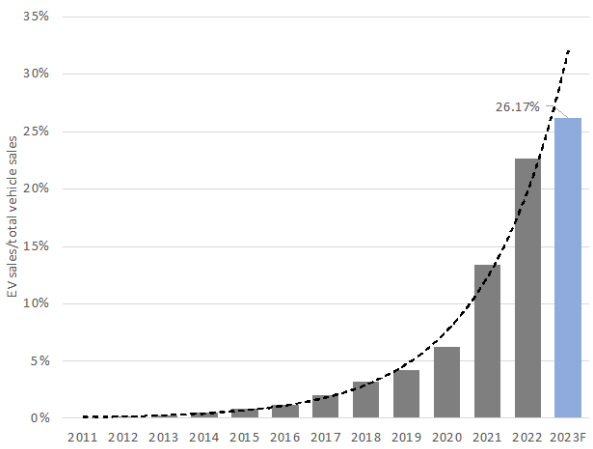
[22] Travelling through the western part of France, we observed regular large banks of TSLA recharge stations, but did not observe a single Tesla vehicle. Looking at European consumer preferences, we concluded that the market would adopt hybrids and PHEVs, over BEVs. This raised questions about the sustainability of the recharge business model and its utilisation outside major metropolitan areas. Unsurprised at both GM and Ford announcements recently partnered with Tesla to use their North American charging network and technologies, primarily because of the cost inefficiency and duplication to establish their own recharge network. Interestingly, all will use the charging port NACS TSLA system, rather than the current industry-standard CCS.

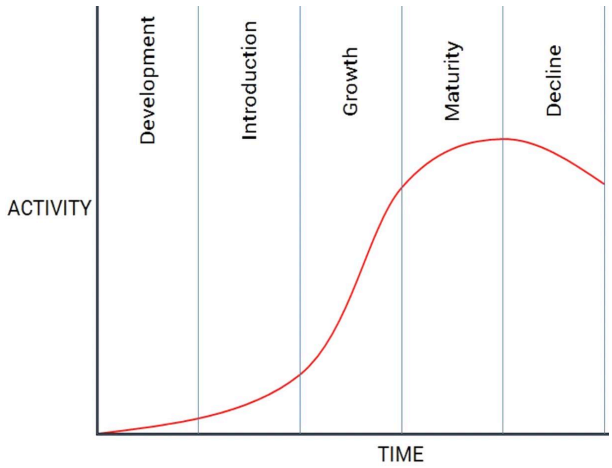
iv. Migration toward hybrids is a global phenomenon. Although this relationship was first observed in Europe, it's quickly spreading amongst Chinese consumers, and inevitably, it will include US customers as well as the technology lends itself to significant economic savings with larger and heavier vehicles in an urban environment.

Where are we in the EV Adoption Cycle?

Although trending strongly upward, global EV sales vary substantially from year to year, and more recently have been negatively disrupted during the covid pandemic and subsequent lockdowns. To smooth out the data irregularity, we divided EV sales over total sales to convert it to a percentage of total vehicles sold (see Figure 17). Using forecast sales from a plethora of specific industry experts, we expect EVs to account for ~26% of all vehicle sales (within our selected markets). Although it has to be noted that this number is strongly skewed by projected Chinese sales, which make up close to 70% of our total estimate. Looking at some US numbers, we could be under-estimating sales by 400k units; the challenge being that, historically, the market has perennially disappointed bullish forecasts.

Figures 17 & 18: Collective EV sales from China, EU & the US over total sales from 2011 to 2023F (left); and sigmoidal growth model (right). We accept that the 2023F estimate maybe a little conservative.





Source: FD

It raises the question – where are we in the product life cycle?

Comparing relative sales[23] in Figure 17 against a sigmoidal growth curve[24] in Figure 18, which is often used to describe the lifecycle of a product, service or technology. From gradual beginnings, "early" EV adoption, then at a certain point, adoption experiences exponential growth until the market approaches saturation; at which point, the intensity of uptake slows and stabilises.

Our ***current interpretation is that the EV market remains in a "growth" stage***, commencing around 2019/20, ***should continue until 2025/26***. After which, the EV market will enter a mature market.

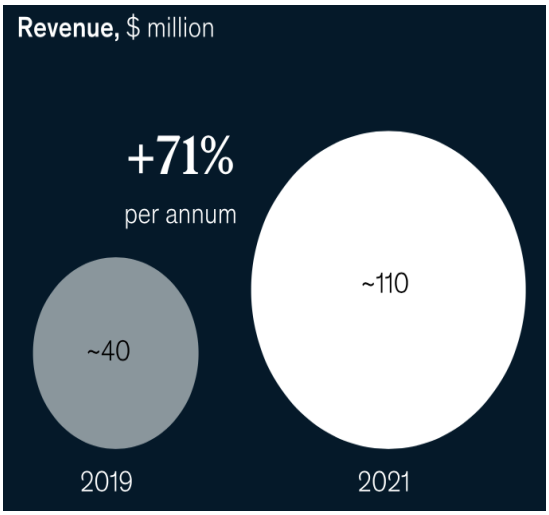
[23] Sales projections only cover China, the United States and Europe, where in two of the markets we look at, EV uptake is ahead of the rest of the world. Any projection using these markets as a template, therefore, will be four or five years ahead of global adoption.

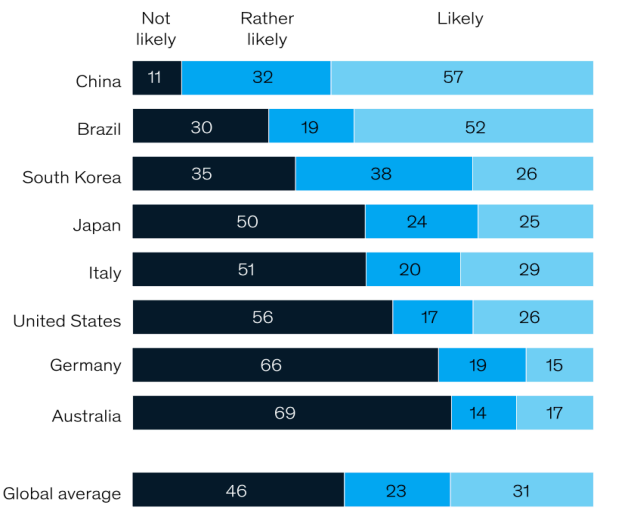
[24] Describing the dynamics of change, with a possible growth trajectory whereby a population becomes established, begining to grow to the point where numbers increase rapidly, until they reach some sort of equilibrium.

Micromobility Developments – Generational Evolution

When we first looked at micromobility a number of years ago, as a future mass transportation event, we were extremely sceptical, despite mobility research coming out of the University of Berkeley[25]. They point out that over 50% of the world's population currently lives in urban areas, and that it is projected to increase to 66% by 2050. When discussing the growth of micromobility, inevitably one has to address where these transportation methods have the greatest impact on consumer choice, and recognise that they are likely to be geographically constrained. Within Europe, the south has historically had a very high share of moped ownership. Countries such as Denmark and Holland have had a long tradition of using bicycles, indeed so have the Chinese. Motorised two-and three-wheelers are ubiquitous when it comes to Southeast Asia or India. Conversely, the United States, Australia, Canada, and most of Eurasia are significantly behind when it comes to micromobility adoption, simply because the distances are so much larger, and in many instances, the infrastructure is not sufficient to either ride.

Figures 19 & 20: Shared e-kickscooter market in Germany has grown by more than 70% CAGR over the past two years (left); and Consideration of mini-mobility usage and implied private-vehicle replacement (% of respondents) (right).





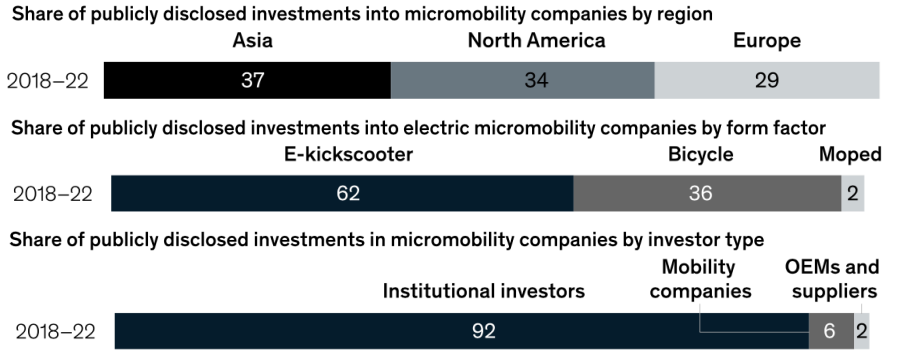
Source: McKinsey (2022)

Continuous technological development has dramatically extended the range and speed of bikes and scooters allowing people to eschew public transport to travel to work, with addition of infrastructure, such as bike lanes. Anecdotally, it appears that many university students are skipping buying their first car, relying instead on various micromobility measures as direct substitutes. Although US centric, Lazarus (2021)[26] points out that whilst adoption of shared mobility services may have been led by younger individuals with higher levels of income and education, more recent evidence suggests

[25] https://tsrc.berkeley.edu/research/resources-library
[26] https://escholarship.org/uc/item/5f1359rd

that adoption is now being led by lower-income people without access to personal vehicles and have become amongst the most significant users of micromobility providers for essential trips; including commuting, accessing healthcare, groceries, goods, and public transport. Which mirrors the change in large carmakers focus, in particular, Toyota, looking past vehicle ownership, concentrating instead on vehicle usage.

Figure 21: Micromobility investments.



Source: McKinsey (2022)

We contend that the impact on transportation is greater than the modest sums involved below, because it's supplementing large expensive item puchases (i.e. vehicles) and requisite public infrastructure.

Simulations of automated public mobility systems by Berkeley researchers claim that the energy efficiency of an electrified, centrally managed fleet significantly exceeds that of private vehicle ownership. Clearly one has to take some of these conclusions with a degree of objectivity, simply because comparing company and personal outputs could be construed as disingenuous, with modelled outputs strongly reliant on the assumptions used, which may, or may not be realistic. But what is clear is where limited means restrict widespread road infrastructure, it follows that micromobility measures in conjunction within centralised public transport system could, for many, be an acceptable substitute. In developing nations in Asia, sub-continent and parts of Africa, such as Nigeria and Egypt, it is increasingly seen as a logical outcome.

Figures 22 to 27: Electric boat, electric two-wheeler, electric bike, low-speed EV, low-speed goods EV, electric scooter.

Source: Various

Why is micromobility important?

Returning to our investment narrative, we iterate that if a technology offers a more efficient production of superior goods and/or services, then general adoption is rapid and unstoppable. Knowing this, we find it remarkable how many jurisdictions have attempted to ban private ownership of scooters (only allowing registered hire companies) despite their universal appeal; regulating their top speed (*e.g.*, Rome, Sweden); banning them on public roads (*e.g.*, UK), others banning them on footpaths (*e.g.*, Singapore), some places banning them altogether (*e.g.* Paris). In short:

i. Micromobility represents a ***fundamental re-evaluation toward transportation networks***, changing the traditional narrative around personal vehicle ownership and for many, it's a realistic substitution; and

ii. ***Challenges traditional assumptions*** for the requirement of large investments into public transport infrastructure in high density settings. This has to be seen in conjunction with advent of remote work and the growing popularity of telecommuting, meaning that overall demand for daily commuting may decrease substantially. Additionally, the rise of e-commerce has changed shopping habits, reducing the need for frequent trips to physical stores.

It's hard not to draw direct parallels with the EV market, that despite a decade of significant official subsidies, the general public have largely eschewed BEVs (with the exception of large prestigious models), but have willingly purchased hybrid vehicles (in all their guises) without any government assistance. Although we think it futile to inhibit the growth in micromobility, which is organic and largely irreversible; governmental angst is understandable given it is such a new field and has in most part not yet received official sanction. A number of legitimate concerns from a regulatory point of view include:

i. **Safety** – a study in the US[27], from September to November 2018, found that at least 190 riders were injured during the study period; half had a severe injury, 84% of which were fractures. At relatively high speeds, inexperienced or reckless riders clearly pose a risk to themselves and others;

ii. **Lack of Regulation** (*e.g.* parking, sidewalk usage, traffic management);

iii. **Infrastructure** (*e.g.* dedicated lanes or parking spaces) to accommodate other road users and pedestrians;

iv. **Liability & Insurance**; and

v. **Negative Public Perception** among some segments in society is putting pressure on governments to regulate sector more strictly.

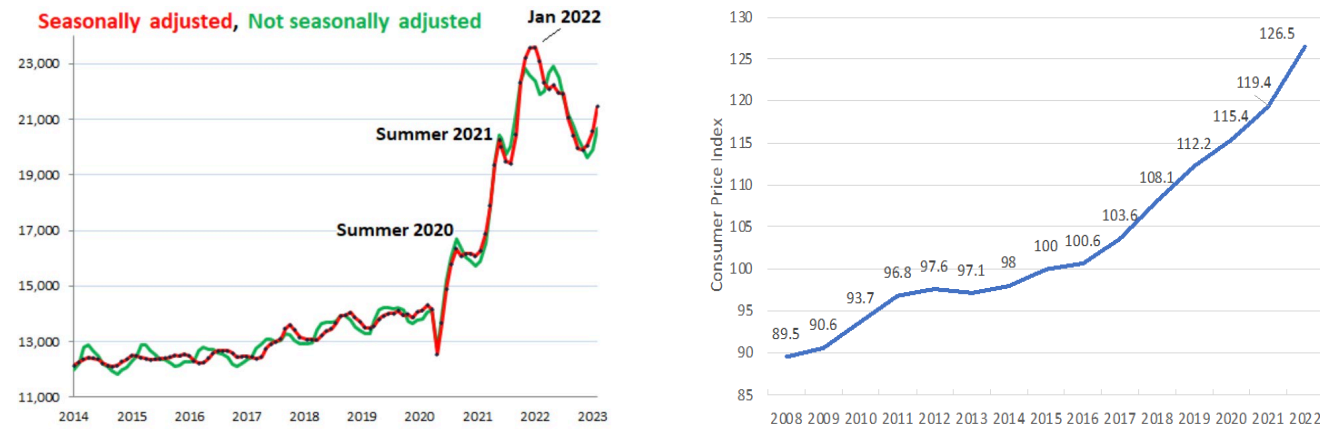
[27] https://www.austintexas.gov/sites/default/files/files/Health/Epidemiology/APH_Dockless_Electric_Scooter_Study_5-2-19.pdf

BEV Price Appreciation – Structural Rigidity?

Q123 from JATO[28] indicate that the Tesla Model Y (267.2k units) outsold the Toyota Corolla (256.4k units) to become the world's best-selling vehicle. What is even more remarkable is the Model Y starts at $47,490, considerably more than the Corolla at $21,550[29]. We suggest, however, that this is an aberration, not a trend in the making, that the customer remains price sensitive.

Over the past decade, the average price of vehicles has increased three times above that of the median wage. The oft given reasons why this price appreciation has occurred include semiconductor shortages (and more recently, the rise in energy prices). But importantly, either reason fails to explain why earlier price rises occurred during a relatively low inflationary period. The actual reasons are far more nuanced, when it comes to manufacturing inputs of EVs, there are a number of key battery components (*e.g.* nickel and aluminium) that require greater capital and energy intensities to acquire, manufacture and assemble. It follows then, that the cost of BEVs will always be structurally higher than the equivalent ICE.

Figures 28 & 29: Manheim used vehicle index (USD) (left); and Consumer price index (CPI) of new car purchases annually in the United Kingdom from 2008 to 2022 (right).



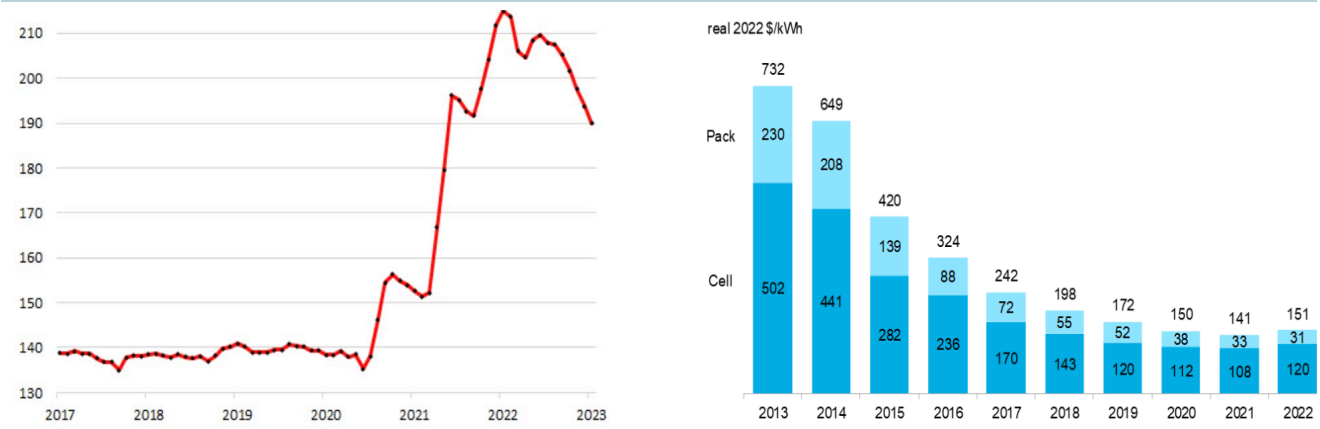
Source: Manheim (2023), ONS (2023), FD

It may seem contradictory, therefore, if we suggest that it is not the actual commodity price itself that is the major contributor to EV price inputs. According to Chemetall, the cost of lithium is relatively immaterial to the production costs of Li-ion batteries[30], only equating to ~1% of the total battery cost. When we modelled NdPr[31] pricing, we found that the commodity price was largely inelastic, a doubling in commodity price only affecting the average BEV price by 0.7%, and a Hybrid was substantially less again, at 0.2%. The

[28] https://thedriven.io/2023/05/26/tesla-model-y-overtakes-corolla-to-be-worlds-best-selling-car-in-2023/
[29] https://www.theverge.com/2023/5/26/23738581/tesla-model-y-ev-record-world-bestselling-car-electric
[30] Copper is required for electrification, lithium and nickel for battery.
[31] REEs, which have unique magnetic, physical, chemical and luminescent properties that allow reduced energy utilisation, permitting significant efficiency gains, miniaturisation, speed, durability and greater thermal stabilities.

point being, assuming *ceteris paribus*, the only way the price of BEVs will fall in time is if the size and the range of these vehicles are lowered as well.

Figures 30 & 31: CPI used vehicle index value (left); and volume-weighted average lithium-ion battery pack and cell price split (values in 2022 dollars), 2013-2022 (right).



Source: BIS (2023), Bloomberg (2022)

What are the key trends driving our key three EV markets?

I. **Europe**: According to JATO[32] in 2015, the average EV was just under €49k, but by H122, that had increased 14% to almost €56k; on average 27% more expensive than an equivalent petrol car. European vehicle manufacturers have focussed on electrifying high-margin premium models and segments, which has kept average EV prices high;

II. **United States**: The average EV was just over €53k in 2015, but increased 20% to ~€64k by 2022; 43% more expensive than an equivalent petrol unit. The domestic preference for large trucks/SUVs has hampered the ability of auto manufacturers to create products that appeal to consumer tastes, and in part, explains why EV growth (in percentage terms) is less than half that of Europe despite comparable living standards and incomes; and

III. **China**: EV prices have declined 52% from just under €67k per unit to <€32k. Importantly, this drop is not the result of economies of scale, rather vehicles made to a particular price point able to meet domestic consumer budgets.

Underlies how difficult it is to model future lithium demand, for example. Not only do you have to (i) account correctly for the number of vehicles to be sold in each market, but (ii) the types of EVs, and (iii) how these quantum's (*e.g.* battery sizes, chemistry) change over time. The key market to model is clearly China, not only does it account for 60 to 70% of all EVs sold globally, the majority of them are unique domestically[33].

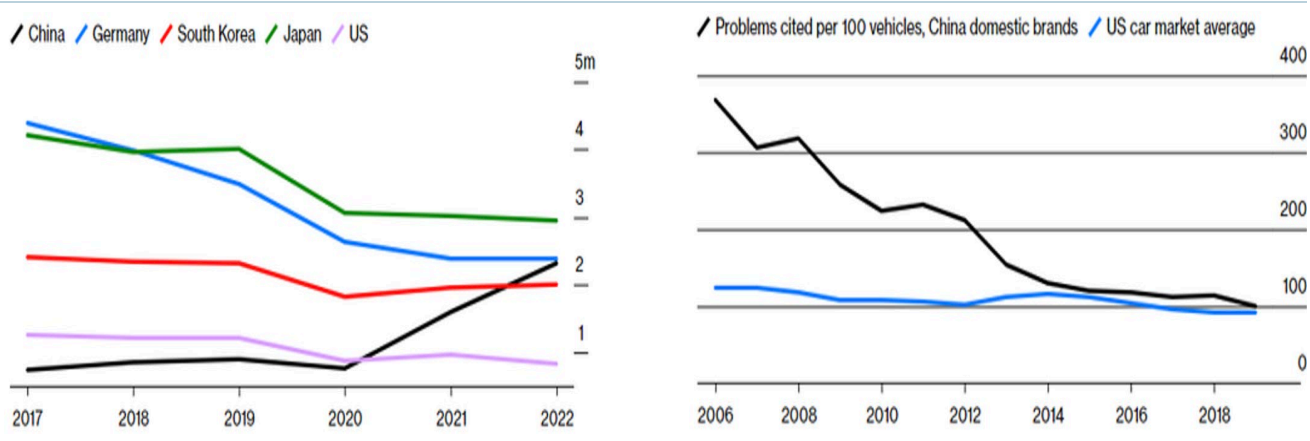
[32] https://www.fleeteurope.com/en/new-energies/europe/features/ev-price-war-china-winning-europe-and-us-losing?

[33] Future lithium and REE models will have to include a "made in China" factor that we will have to quantify, to accurately reflect size of domestic batteries and drive chains. Current model may overstate end use demand in the medium-term.

China to be the World's Largest Car Exporter?

Q123, China exported 1.1 million vehicles to become the world's largest vehicle exporter, with Japan second at ~954k units. Furthermore, BYD has overtaken Tesla to be the largest EV maker, with domestic EV sales representing approximately two-thirds of the entire globe. Although China has been the world's largest car market and producer since 2009, what has surprised (even veteran observers) is how quickly China has acquired market share of the global vehicle market; overtaking Germany in 2022 to become the world's second-largest exporter of cars (by volume - 2.5m passenger vehicles[34]), just behind Japan (see Figure 32); up 56.7% from the pcp. Back in 2021, China was the fourth largest exporter by volume, but it was only twelfth by value, behind both the Czech Republic and Slovakia.

Figures 32 & 33: Annual passenger car exports, with China now matching Germany (note that 2022 numbers do not include December) (left); and problems cited per 100 Chinese vehicles has converged with the US average, indicating improvement in quality demonstrating their expertise in both BEVs and ICEs (right).



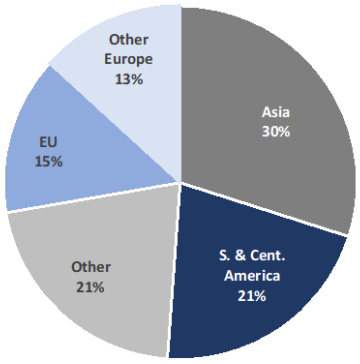
Source: Bloomberg (2023)

According to the *Telegraph*, 30 new EV marques have made applications to sell vehicles in the UK, the vast majority of those are Chinese in origin. It is a time-honoured strategy, countries (including Japan and South Korea) have entered the market by producing cheap and reliable cars, and then later developing more desirable models and brands. Unsurprisingly, like all new entrants, the quality of Chinese vehicles is quickly approaching the average of all vehicles sold (see Figure 33); not dissimilar to perceived poor quality of Japanese cars from the 1970's, by comparison to setting the benchmark now[35].

There is a certain inevitability that China will overtake Japan as the largest exporter within the next 12 months, primarily through volume growth toward Southeast Asia and the EU; filling the void left by European car makers focused on high-value units to the exclusion of cheaper affordable vehicles.

[34] Overall, 3.1m including commercial vehicles (CAAM).
[35] https://eu.usatoday.com/story/money/cars/2022/11/18/domestic-vehicle-brands-among-least-reliable/10719288002/

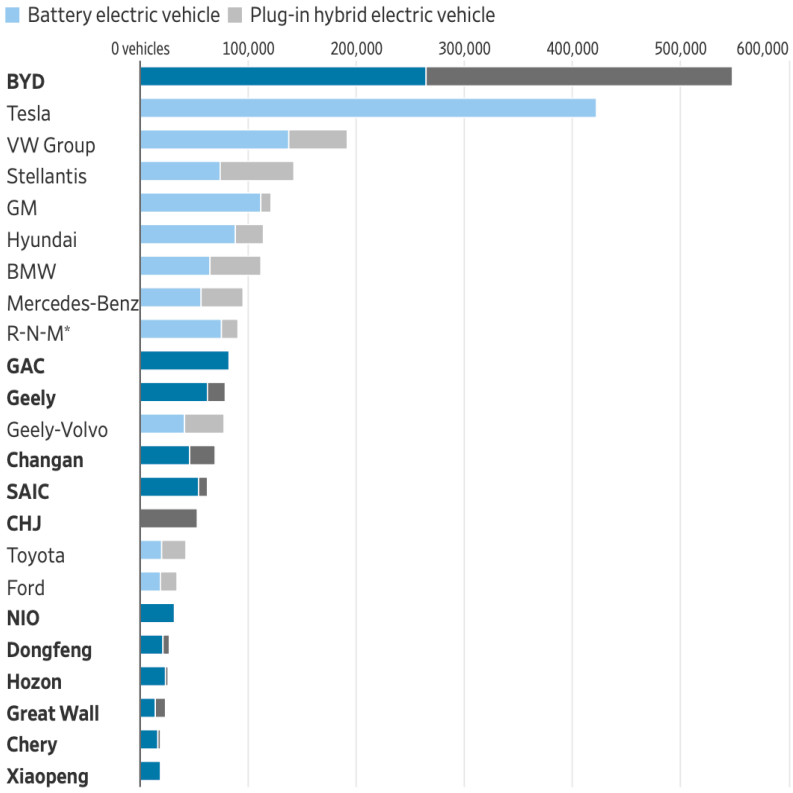
Figures 34: China's vehicle exports by destination, 2021 – mostly to Europe and Asia.



Source: Bloomberg (2022), FD

The key difference when comparing current day China with previous rising industrial powerhouses (*e.g.* Japan, Germany, Korea) is that the Middle Kingdom is increasingly dominating particular commodities, and in particular, the global processing and refining of minerals, allowing it to transition to become a mercantilist powerhouse, cornering the market in a number of critical EV battery components (see Figure 38).

Figure 35: Global EV sales Q123 (Chinese companies in bold).



Source: EV Volumes (2023)

Some forecasters suggest that China could export as many as 5.5m units by 2030; with more than half of them an EV of some description. If this forecast were to be true, taking into account our forecast of total vehicles sold globally (see Figure 1), this implies two eventualities:

I. In the future, the Middle Kingdom vehicle production will displace current manufacturers with the number of units they fabricate falling significantly; and

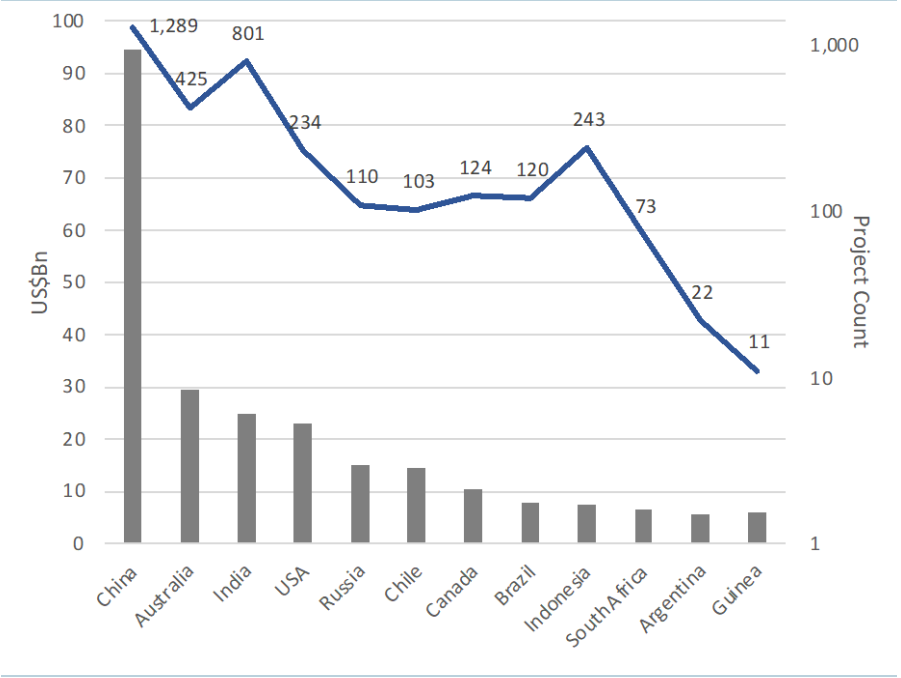
II. On current trends, China will account for ~40% of the seaborne export market by the end of the decade.

The recourse for economic retaliation by countries working to protect their own car industries will be limited. Not only does China supply a significant portion of refined commodities, it is increasingly an integral component manufacturer, and it is also a major market on which European car makers rely. According

to the *FT*, Volkswagen, relies on China for at least half its annual net profits[36], and a similar situation can be said for Korean, Japanese and American car makers. With much of the Western world suffering from a cost-of-living crisis due to ongoing high inflation, which is strongly affecting vehicle prices, the value proposition offered by cheaper Chinese alternatives will inevitably help with their sales profile and market share.

What we find remarkable is that India is just behind Australia in terms of mining investment, with Canada falling to seventh from being the largest commodities explorer little more than a decade ago. Which underlies the fact that all emerging geopolitical powers are going to have a meals intensive developmental period.

Figure 36: Top 20 countries for mining (only included active projects with planned stats in 2023).

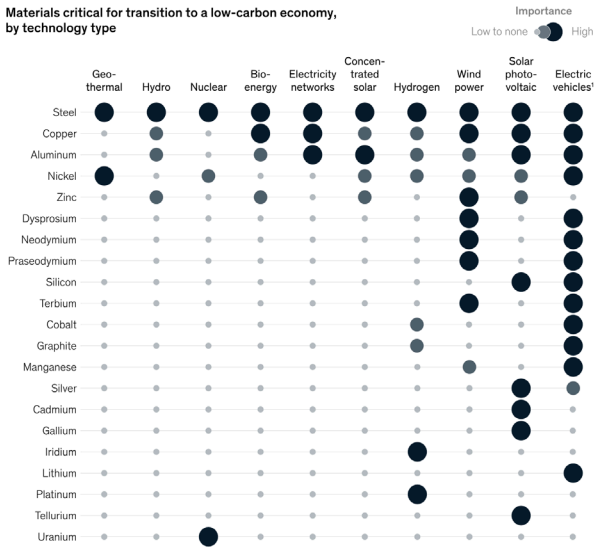


Source: Industrial Info Resources (2023), FD

[36] In November last year, German Chancellor Scholz travelled to Beijing in the company of the chief executives of Volkswagen, BMW, BASF, Bayer and Deutsche Bank; and stated that "*even in changed circumstances, China remains an important business and trading partner for Germany and Europe - we don't want to decouple from it*." (https://www.politico.eu/article/olaf-scholz-we-dont-want-to-decouple-from-china-but-cant-be-overreliant/). It also provides a watershed moment to many, indicating the increasing reliance of German manufacturing on China sourced inputs, whether they be commodity and/or componentry. The reality being, Germany is unable to decouple from China in the foreseeable future.

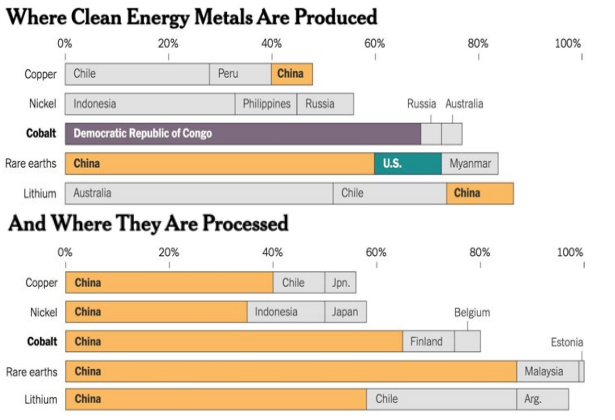
Critical Commodity Scarcity Increasing

Figure 37: Metals intensity per technology going forward, with EV's being very metals intensive.



Source: McKinsey (2022)

Figure 38: Production of key resources are highly concentrated, (top); with China dominating refining and processing (bottom).



Source: NYTimes (2022)

The vast majority of research covering the migration from authigenic carbon sources to more greener technologies agree that the transition will require substantially greater metals intensity, with estimates varying from 100% to 300% of current usage depending on the application. Not just because of the additional effort required to acquire the necessary materials, but refining processes, and the energy required to manufacture new methodologies of power generation, and/or motion (*e.g.* Figure 37). It follows that Western nations will need to dramatically increase their requirement for commodities in the very near future, and in turn, will be far more reliant on those countries/entities that supply them. The prevailing logic being that whatever commodity is needed, it would be readily traded under WTO rules. On that basis, companies/countries over the past three decades have actively relocated the majority of their global smelting and refining operations in most metals, to China (see Figure 38); which is primarily based around cheap authigenic coal-fired power[37].

The second assumption behind this move was the prevailing economic narrative around the continual ability to secure sufficient supplies in whatever commodity needed [38]. Furthermore, whatever shortages ensued, it would be resolved via the "*Law of Supply*"; *ceteris paribus*, as the price of a good or service increases, the additional incentive would induce a greater quantity of that good or service also. For example, the current shortage of lithium will eventually be solved by the raising of venture capital, mineral exploration, development and production. The time that process takes in reality, however, is considerable. For a traditional salar lithium deposit, the definition of a simple reservoir and the point at which it enters production can take as little as five years. For a copper porphyry, however, it may need $150m and five years just for drilling, then several billion-construction capex; the whole process taking several decades from delineation to nameplate production.

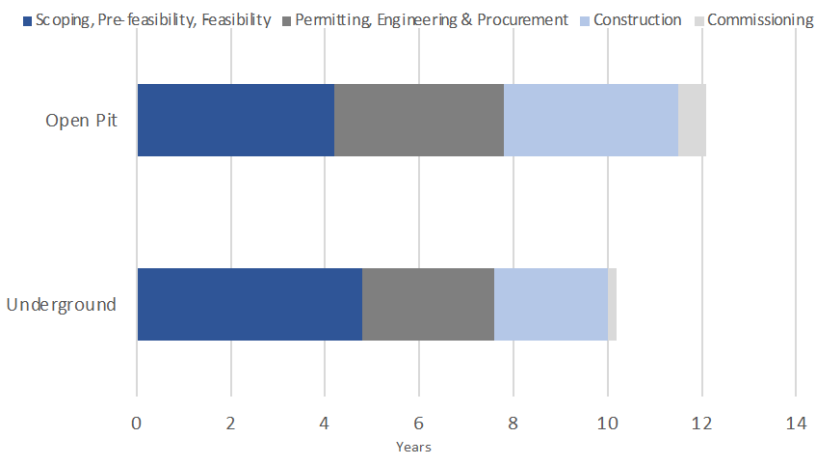
One such is example CATL, which has emerged from nascent beginnings to become the world's largest lithium manufacturer in under a decade. We have previously noted China's efforts in securing a significant portion of the

[37] China's domestic production of 4.6Bnt in 2022, +10% over the pcp; with Mar-23's output of 433Mt a record-high. Estimated global consumption (IEA, 2023) of ~8Bt in 2023.

[38] In the case of mining, greater resources would be allocated to exploration, capex and existing productive capacities until additional supply entered the market to resolve those shortages, with the prevailing price falling to the marginal cost of production at the upper end of the relevant cost curve.

available lithium projects globally[39], which raises the obvious question – why would China sell unprocessed/processed lithium carbonate/ hydroxide to Western customers? The difficulty in establishing alternate processing centres is the degree of willingness of capital to go up against the Middle Kingdom's SOEs, who have historically been willing to produce at below cost in order to put competitors out of business. Its economic ascent is based on an inbuilt energy advantage over its competitors. Looking at manufacturing output[40], China's output is approximately double that of the US, 500% greater than Germany and 950% greater than that of Korea.

Figure 39: The average length of time to develop a new copper mine is now over a decade (Based on mines that started-up in, and after, 2010).



Source: Bloomberg (2023), CRU (2023), FD

The reason why there has been a sea change in so many projects now being funded by SOEs, is the increasing difficulty in securing debt/equity in mining venture, in large part, over ESG concerns (which we think are misplaced). Collectively, this additional green-tape acts as a barrier to capital investment from a Western perspective. The Chinese, unencumbered by such niceties are picking up substantial resources for relatively modest outlays.

Continuing to follow this line of logic, it is clearly more advantageous to China to sell the battery packs; and eventually, sell the EVs? Despite only having ~8% of global reserves (which are either very low grade[41] or chemically[42] very difficult to extract), and approximately 15% of annual primary production, due to its large battery cell manufacturing capacity (893GWh); in 2022 China controlled ~60% of the world's raw lithium refining, ~77% of the world's cell capacity[43] and ~69% of the world's lithium component manufacturing. It is becoming increasingly obvious that vehicle manufacturers are reliant on existing Chinese supply chains, with very little, if any, third party supplies available. Unsurprisingly, BMW have announced that they intend to cease

[39] For example, Gochin, a Chinese company, has offered to invest $10Bn in Afghanistan's lithium reserves, an improbable move geopolitically, with no other country recognising the Taliban government.https://www.internationalnewsandviews.com/china-makes-10-billion-offer-to-taliban-for-lithium-reserves/ Alternatively, significant lithium resources have been discovered in Zimbabwe, Namibia, Ghana, the Democratic Republic of the Congo, and Mali; all would struggle to attract Western finance, but all those jurisdictions have a close relationship with China. Three Zambian and two Zimbabwean spodumene mines recently financed by SOE's, are in the midst of commencing commercial operations.

[40] https://www.macrotrends.net/countries/ranking/manufacturing-output

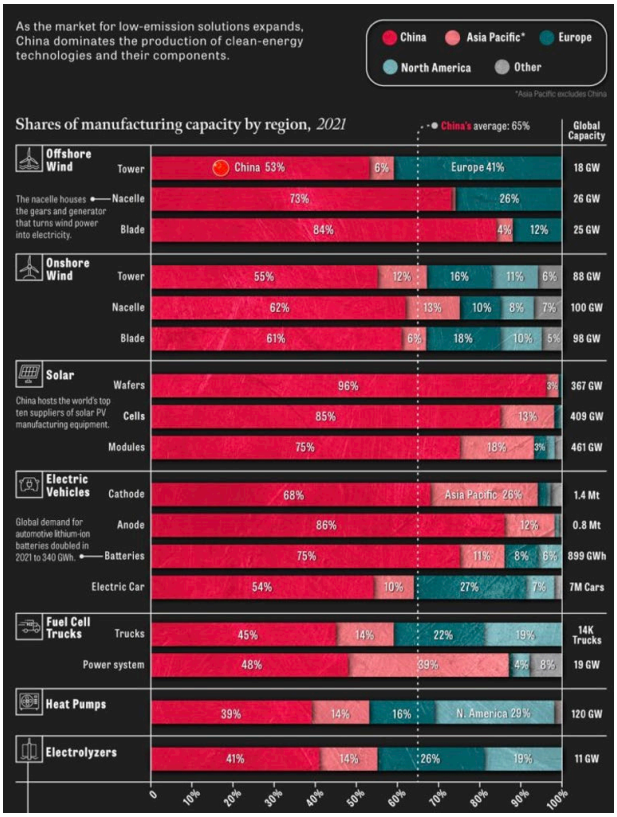
[41] China's publicly known lepidolite deposits grade between 0.2 to 0.8% lithium, with average mined grades forecast between 0.28 and 0.5% (GS, 2022). Compared with a typical Australian spodumene deposit grading ~1.1 to 1.4% Li_2O.

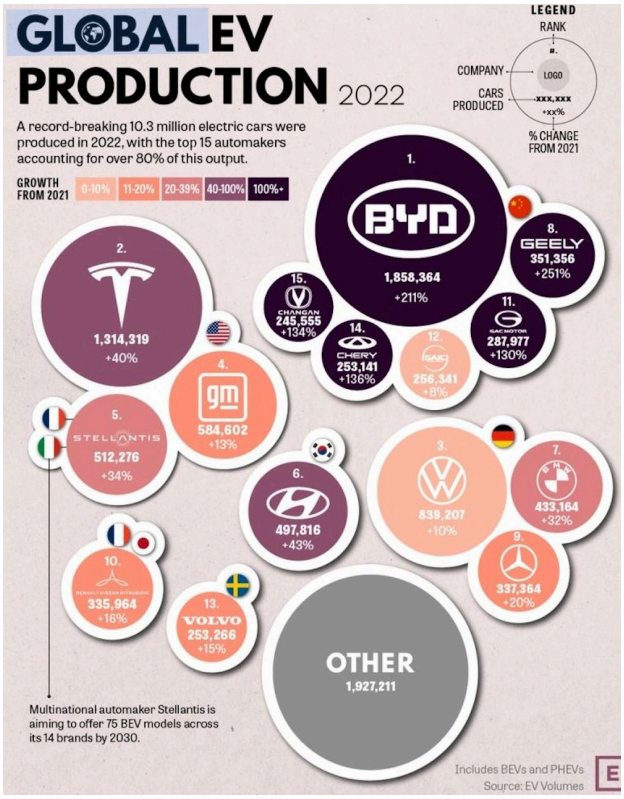
[42] Chinese DLE operations remain an economic challenge due to high magnesium to lithium halide ratios.

[43] https://www.visualcapitalist.com/chinas-dominance-in-battery-manufacturing/

production of the electric Mini in the UK and relocate its facilities to China[44]. It follows that other car makers will also have to eventually move EV production to China to secure the raw resources. The only country attempting to fully insulate its supply chain away from China (to date), has been Japan.

Figures 40 & 41: Where are clean-energy technologies being manufactured – increasingly, the answer is from within China, using technologies originally developed in the West (left); and World's top 15 plug-in car manufacturers in 2022; already dominated by the Chinese, with its market share to grow. China also owns Volvo (right).





Source: Visual Capitalist (2023), EV Volumes (2023)

Recent trend from investing in minerals and energy exploration, and the export of processing and manufacturing to places such as China, has left a capability gap in most Western economies. China has taken the opportunity to pursue a mercantilist direction, a practice that uses governmental regulation to secure raw materials in order to value-add. From a strategic point of view, it is in the best interests of the nation state to firstly secure exclusive rights to various raw materials; then manufacture and value add, and finally export in order to run a trade surplus. In regards to critical commodities, no matter what the price point, it better serves the mercantilist to withhold supply to prevent your opponent from competing economically. Alternatively, set pricing for competitors at ruinously high levels to establish dominance, until technological obsolesce and/or war alters the economic landscape.

[44] https://insideevs.com/news/616952/bmw-said-move-mini-electric-vehicle-production-from-uk-to-china/

Figure 42: Economic centre of gravity map, migrating toward Asia, in particular, recent growth from India and Indonesia. By 2030, some estimates have India as the world's second largest economy on a PPP basis[45], the US third, Japan forth, Indonesia/Germany fighting to be fifth/sixth.

Source: Economist

On a PPP basis, from 2023 onwards, the BRIC (Brazil, Russia, India, and China and others) grouping is now larger, economically, than the G7 (Canada, France, Germany, Italy, Japan, the UK, and the US); a difference that will only increase in time as GDP comparisons converge.

Companies attempting to circumnavigate this eventuality and diversify their risk have established manufacturing faculties in other jurisdictions. The fallacy behind such a move is known as the "*double paradox*", as illustrated behind Samsung's decision to shift production from China to Vietnam, without comprehending that many, if not most of the components still need to be manufactured out of China. Geopolitically, rather than connecting these emerging economies more closely to the West, many of these decoupling attempts have often meant that these new manufacturing centres end up, ironically, being more economically dependent upon the Middle Kingdom.

[45] PPP is an economic concept that compares the relative purchasing power of different currencies. It measures the amount of goods and services that can be purchased with a unit of currency in different countries, taking into account the exchange rates and the cost of living. How does this compare with GDP? GDP is a monetary measure of the total value of all goods and services produced within a country's borders. For example, the average price of a cappuccino in Denmark is ~$5.61 per cup, compared with ~$1.90 in Russia (https://www.numbeo.com/cost-of-living/country_price_rankings?itemId=114). Both use identical amounts of commodities (*e.g.*, milk, coffee beans, energy), bought internationally for similar prices. PPP is a far more accurate measure for consumption and resultant output. GDP is better for measuring a country's relative wealth, hence the price of the cappuccino in Denmark.

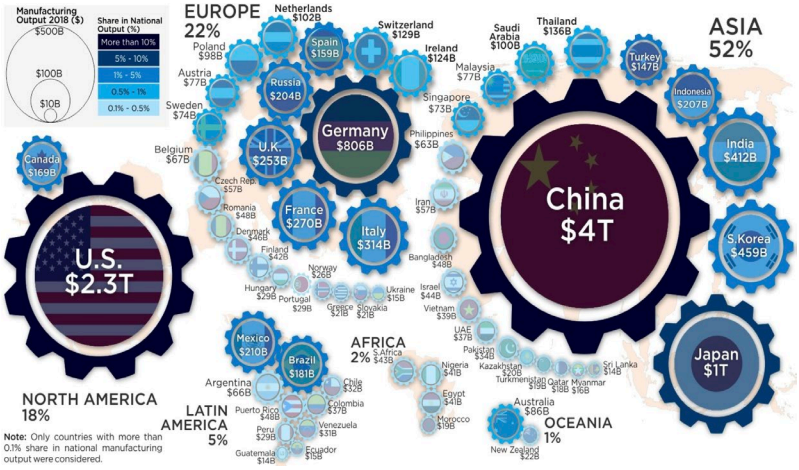
Key points being:

I. ***Resources are geologically and***, in many instances, ***geographically specific***. Multiple commodities occur in only several places globally, in sufficient quantities to be economic;

II. There are ***very few places globally, that have sufficient base-load energy to allow the establishment of processing***, refining needed for manufacturing – China is one of those countries; and

III. Any attempt to ***decouple from Chinese supply chains are fraught with intricate dependencies***. Full separation for most jurisdictions is next to impossible in the short-term, with the exception being Japan.

Figure 43: Global manufacturing output. China's output is still growing at the expense of the rest of the world.



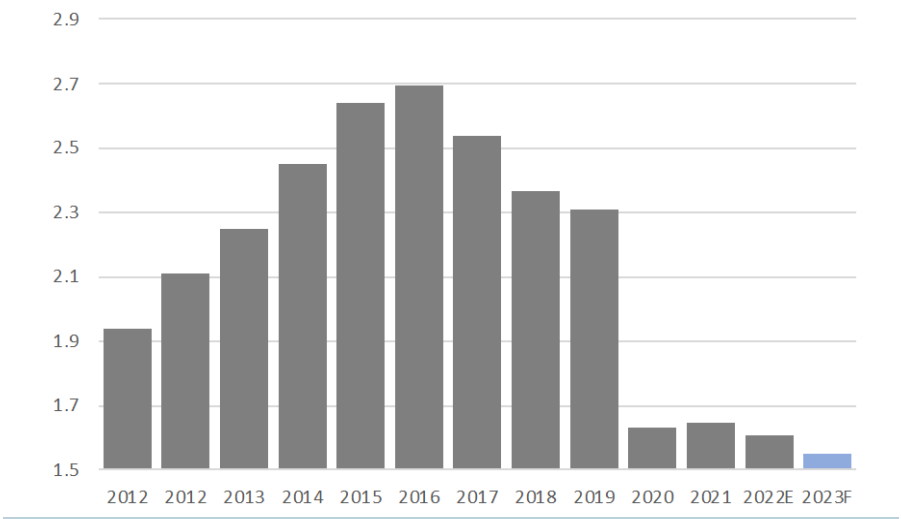
Source: howmuch.net (2020)

Figure 43 is based on 2019 numbers, at the time China accounted for 28.7% of global manufacturing, 12% ahead of the United States. We think China's global output has grown to ~33-34% presently.

Appendix A - Vehicle Sales United Kingdom

The UK used car market in 2022 declined -8.5%, along with the new car market falling to a 30-year low. Much of this drop was blamed on semi-conductor shortages, but this a simplistic explanation. According to Roland Berger, 62% of the automotive market and 57% of the industrial market relies on analogue/mixed signal chips, microcontroller units, or specialty components such as micro-electromechanical systems, which are legacy semiconductor technologies, not high-end computation chips[46]. This explanation reflects industry and analytical dissonance as to the real underlying reasons why not only has UK vehicle ownership has fallen precipitously, but globally for the past six years (see Figure 44). A thematic that we have returned to numerous times throughout this note with many current owners preferring to hang on to their current vehicles than upgrade, which incidentally, again is a global trend.

Figure 44: Number of newly registered UK vehicles.



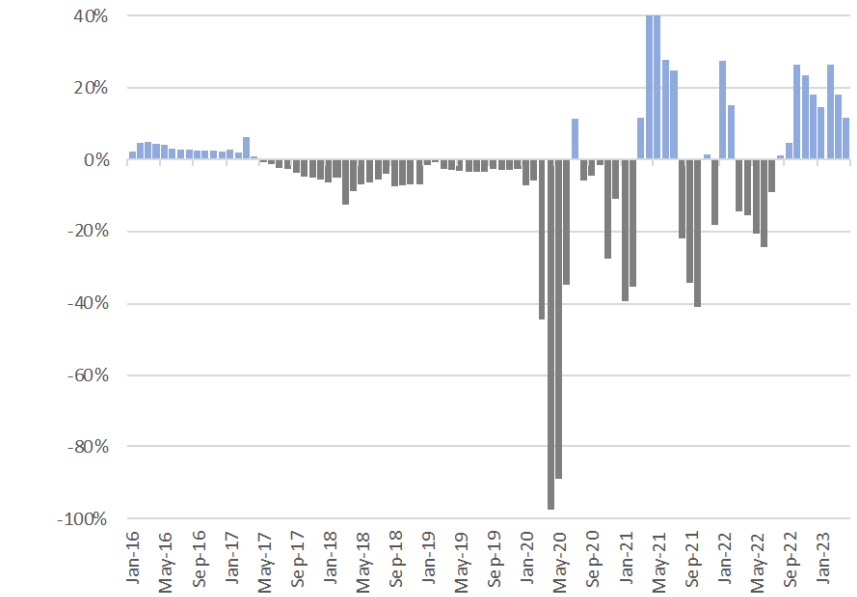
Source: FD

[46] Which are in oversupply due to a 30% softening in consumer demand for electronics.

A large part of the underlying reason could be that between 2011 and 2020, UK new car prices approximately doubled, whilst average UK wages only grew 20% in nominal terms. This inflationary climb is accelerating, according to *Autotrader*, the average price of a new car has risen by £12k (or 43%) over a four-year period from 2018 onward; although we suspect that it is, in part, related to more expensive EV models entering the market. But it could explain why the proportion of those aged 17-20 holding a driving licence has fallen from 48% in the early 1990s, to below 30% presently. It also reflects changing lifestyles, increased regulation, insurance, government fees and alternate opportunities given by the arrival of new technologies (*e.g.* micromobility options).

With the exception of some statistically high sales periods as the result of ending covid lockdowns, vehicle sales have been in continual decline since May 2017 despite immigration into the UK adding 2.5 million to the national population over that period.

Figure 45: Growth/decline in newly registered cars in the UK from 2016 to April 2023 (monthly y-o-y increase/decrease in percent).



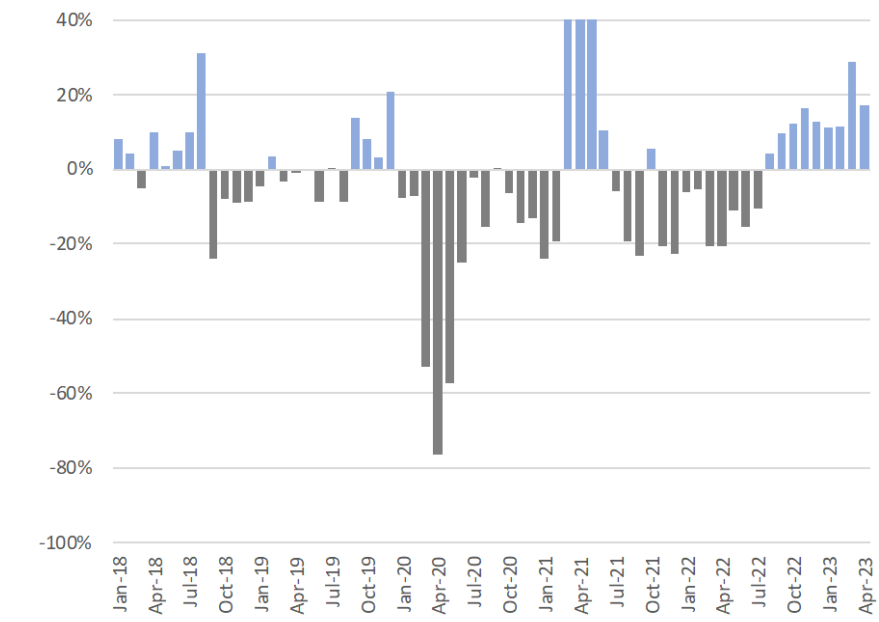
Source: FD

Appendix B - Vehicle Sales Europe

The European new car market recorded another decline, with overall volumes at levels not seen since 1985. The official reasons given by the ACEA[47] range from Brexit (thought that it only affected the UK?), the coronavirus pandemic, semiconductor supply bottlenecks, the war in Ukraine (and its impact on oil prices), energy costs and declining disposable incomes. These reasons do not, however, explain why sales have been falling for at least five years, nor address increasing purchase expense in real terms. Although it has to be mentioned that part of the reason why vehicles in general are more costly is the fact that they are becoming larger to accommodate new road safety rules, including measures such as airbags, side impact bars, and crumple zones; furthermore, they are also reflecting changing customer preferences[48] that include taller and roomier cabins, all adds significantly to unit costs, further diminishing customer affordability.

Despite falling volumes, EU automotive manufacturers remain reasonably profitable, the backlog in sales allowing car companies to prioritise high profit-margin vehicles, to the exclusion of some volume models.

Figure 46: Newly registered European vehicles from January 2018 to April 2023.



Source: FD

Looking ahead, European energy shortages are likely to continue as a multi-year issue, with increased industry and transportation costs making the region less competitive in the long-term. Subsidies needed to protect the disadvantaged will inevitably increase public debt levels, will in turn, limit the ability of the ECB to raise rates to reign in on-going inflationary pressures.

[47] European Automobile Manufacturers Association.
[48] In a nod to the future, in January this year, 51.3% of all sales in the EU were, for the first time, SUVs.

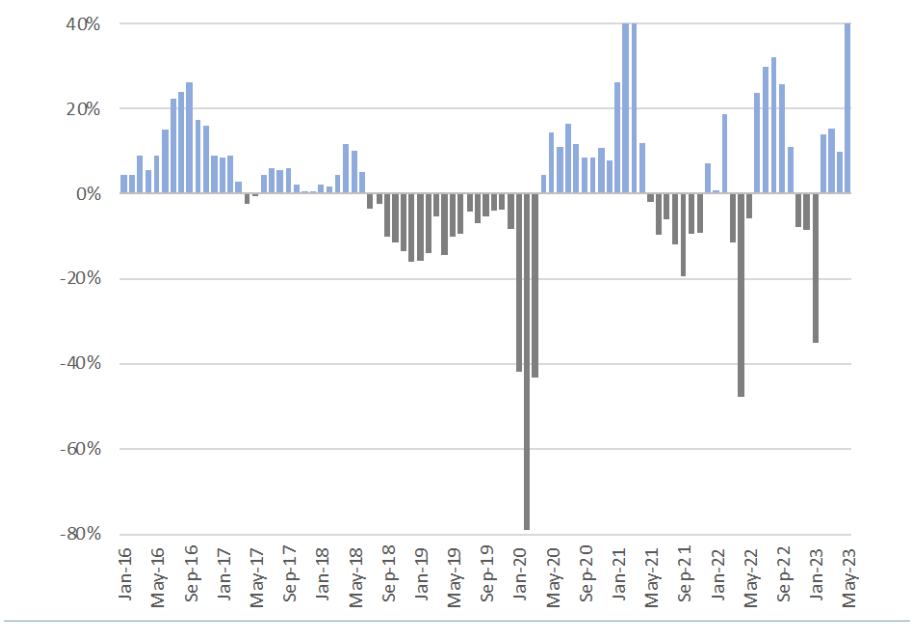
Implying that even if vehicle sales do improve, volume increases will be marginal at best.

Appendix C - Vehicle Sales China

In 2022, China recorded its first drop in automotive sales since 1990, with many consumers avoiding big-ticket purchases amid an uncertain outlook for the economy. Even before the official coronavirus shutdown, numerous factories were closing and sending people home to avoid any possible infection.

China has been as an automotive market giant in the making, with consensus[49] once predicting 28m units sold pa by 2025 (annual passenger vehicle in 2022 was 23.84m units). The rationale being, whereas ~800 out of 1,000 people own vehicles in the United States, in China, that ratio is ~190, with the vast majority of those living in larger cities. At this point, we merely point out that there are structural differences between the two markets (see discussion on p. 19-20) coupled with micromobility advances. Needless to say, we are unsure long-term as to the underlying level of vehicle demand or consumer growth given the potential for Chinese governmental intervention.

Figure 47: Growth/decline in newly registered cars in China from January 2016 to April 2023 (monthly y-o-y increase/decrease in percent) .



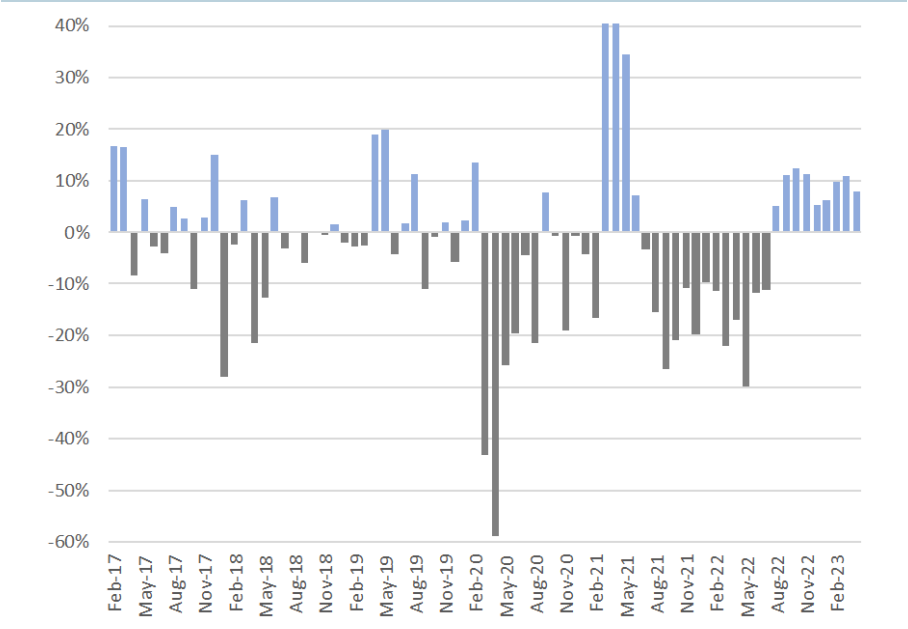
Source: FD

[49] Vehicle ownership in China is highly regulated. But that is not just a unique feature to China, Government policy has always been a driving force in automotive development, and as long-time car industry observers recognise, auto industry/ government interaction is normal business practice. For example, Angela Merkel enlisting David Cameron's support in 2013 to delay certain emissions targets, because none of the German car makers could meet them in time. Or the gradual outlawing of diesel engines in California as a result of coarse particulate matter generation; or even the punitive EV tax regime in Norway.

Appendix D - Vehicle Sales United States

Unsurprisingly, given what we have reported in other major car markets, 2022 was the worst sales year for American vehicles since 2011. Supply chain shortages[50] and higher production costs[51] meant that the average vehicle rose >4% to $46,400 per unit. Slow sales are expected to continue because of higher interest rates and general economic conditions slow. Continued new vehicle pricing increases, declining trade-in values[52], a forecast recession H223, and higher interest rates[53]; will collectively, negatively impact vehicle affordability.

Figure 48: Newly registered US vehicles from January 2018 to January 2023.



Source: FD

[50] Inventory shortages have had an impact, although the average (November 2022) was around 53 days, which is close to the industry "ideal" 60 days.

[51] Despite falling raw material costs, higher non-commodity costs by supplier (*e.g.* diesel, freight, shipping, logistics, labour, electricity) are passing on to various automakers.

[52] Declining used-car prices are pushing down the value of trade-ins, which has the effect of discouraging potential buyers who use the residual equity to offset the higher purchase price of a new vehicle.

[53] Consensus suggests that the Fed will stop at current levels.

Disclosures

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Gaius is approaching three decades of experience in commodities, primarily in Australia and the UK, including underground and surface mining operations, exploration, corporate finance, mineral economics and as a resource analyst; for WMC, Outokumpu, Mincor, DJ Carmichael, WHI Securities, WH Ireland, HD Capital, Numis, Metalytics, Aegis Equities and Smartkarma. He has conducted fundamental supply and demand analysis on iron ore, nickel, REEs, and lithium, among other commodities. As an analyst, he has specialised primarily in the mid-tier/junior mining sectors, covering numerous mining stocks on the ASX, LSE and AIM.

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