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Where's a copper when you want one?

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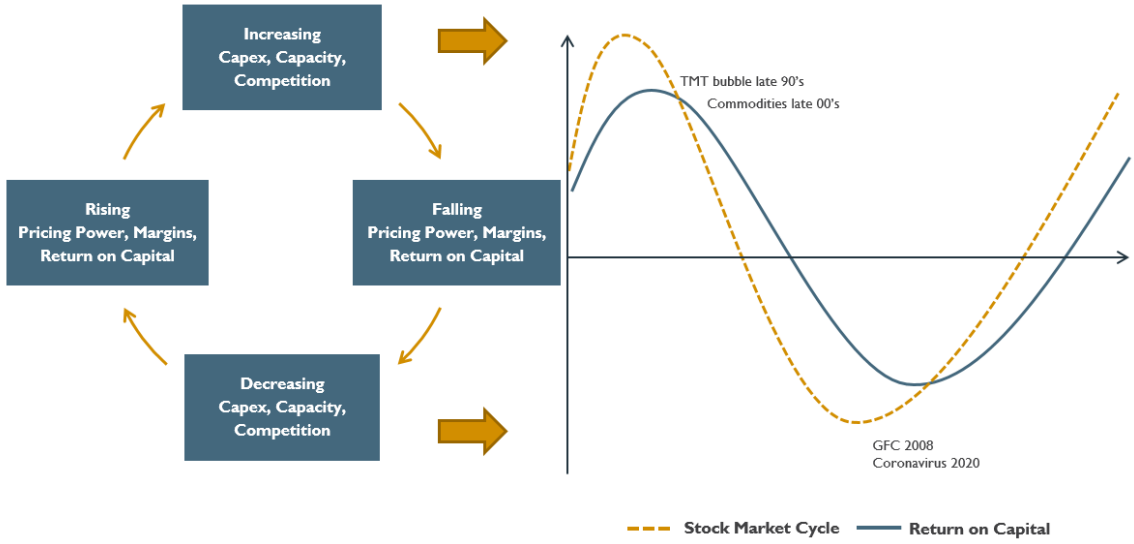
A CAPITAL CYCLE ANALYSIS OF THE COPPER INDUSTRY

The capital cycle approach has been 40 years in the making for the team at Hosking Partners. We have learnt that rewards from this approach have been anything but linear. And whilst the returns may have been lumpy, the underlying model has stood the test of time: identifying industries where returns are likely to sustain or improve, whilst simultaneously avoiding capital-hungry, bubbly sectors. A foundational tenet that underpins the analytical power of the capital cycle is a disciplined focus on supply. The more capital that enters an industry, all else equal, the lower returns are for the remaining capital and vice versa. The underlying supply of whatever commodity, good or service the industry provides is a function of this inflow – or outflow – of capital. This capital cycle approach is not limited to old school metal-bashing industries. For instance, the more digital TV streaming series that are launched, the lower the returns on the existing library of content. And, as we have learnt over the decades, the supply of 'stuff' is demonstrably easier to quantify than future demand for it: most industrial and service capacity is entirely tangible, or measurable in some other way, thus the range of outcomes over a given time period is narrower for supply than demand. Capacity additions are usually flagged. This approach is set out in the graphic below[1], which we hope will be familiar to our regular readers. It goes without saying that taking this supply-focused, capital cycle approach means an investor must use a genuinely long-term horizon. In many instances supply-driven industry investment cycles are measured in decades rather than years, as our overview of the copper mining sector that follows demonstrates.



[1] Hosking Partners

Demand is storytelling, supply is measurement

Despite the obvious tangibility of supply, Wall Street's commodity analysts are overwhelmingly focused on forward-looking demand. In the short term, market commentators fret over what a Chinese government infrastructure package might mean for iron ore consumption, or what the opening of economies after Covid lockdown could do to oil prices. As advertisements for financial spread betting firms attest, commodity speculation is a macro fortune-teller's paradise! Longer term, there is a more sensible debate over how much of the earth will need to be dug up in order to decarbonise and electrify our energy system. The task is daunting. After ten years and $3.4 trillion spent on renewables, we have moved the proportion of our energy supplied by fossil fuels from 82% to 81%[2]. Long-range commodity demand forecasts are sensitive to thousands of input variables, many of which are imponderable. Flexing assumptions on everything from global GDP growth, to the adoption rate of electric vehicles, to the proportion of an electricity grid that can be powered by renewables, results in huge variations in the long-run demand forecasts for key transition materials like copper. The further out one looks, the more sensitive forecasts become to those input variables, and the greater the margin of error. We are early into the net zero movie, and where it ends is anyone's guess. One of our favourite quotes – often used in office discussions – comes from Danish physicist Nils Bohr: "*Prediction is very difficult, especially about the future*".

As capital cycle investors our prerogative is to stand back and dispassionately look at the supply side. Supply side analysis may be less glamorous and perhaps even less stimulating to most of us, keen as we are for story-telling and narrative. But it is foundational to well-grounded industry analysis.

Copper – improving our lives for 20,000 years

The story of copper is the story of human advancement. It was probably the first metal ever used by humans and for over five millennia has been used in jewellery, weapons and, when alloyed with tin, as bronze coins. In the 1800s the discovery of electricity transformed the role of *aes cyprium*[3]. Copper's conductivity, then as now, made the metal crucial in an electrified world. From lights through to telegrams, huge networks of copper wires underpinned a technological revolution that spanned the globe. What is fascinating, to supply-obsessed observers, is that many of the mines excavated to build out this first iteration of electrification are still being mined today – albeit at depths and grades that would have been unfathomable to the initial engineering teams[4].

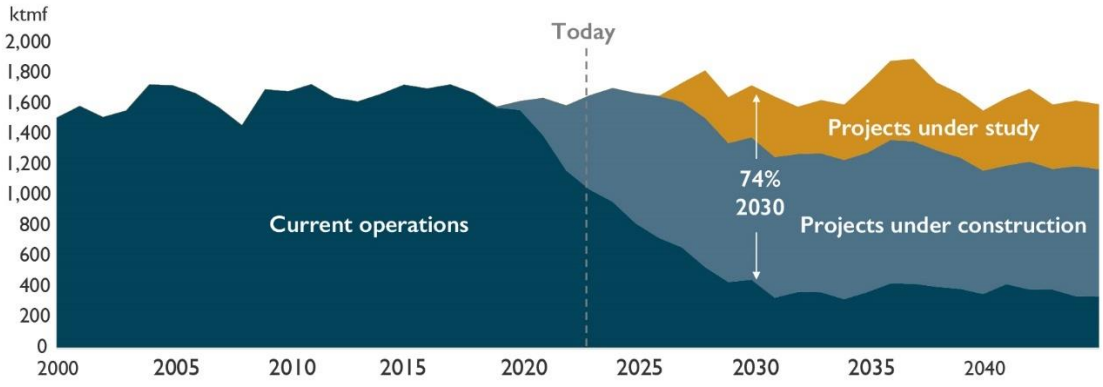
[2] IEA
[3] The Latin for copper derived from the name of the island of Cyprus
[4] For example, the Bingham Canyon mine in Utah, founded in 1848, is currently 1.2km deep, producing 143Kt of copper for Rio Tinto

Today, copper ore has an average purity (or 'grade') of below 1%. This means that a metric tonne of ore will contain less than 1kg of copper metal. As such, it is extremely energy intensive – and therefore carbon intensive – to mine[5]. The supply of this mined copper ore is highly geographically concentrated. The top two producers, Chile and Peru, account for close to 40% of the world's 21 million tonnes of production and their ever-deeper mines are seeing continued grade depletion. The downstream part of the copper value chain is even more concentrated than mining. China accounts for almost 50% of the world's smelting capacity, and 40% of its refining capacity – a reflection of the long-termism applied to strategic industries in China that has not been replicated in western supply chains. This high level of market concentration also means copper is becoming a strategic resource, with supply chains increasingly less adaptable.

The future of supply

In Chile, the world's largest producer of copper – state-owned Codelco – provides data on its production profile. As the chart below shows, for much of the past two decades, the production at its mines has remained flat at around 1.6 million tonnes per annum. This is a result of consistent under-investment and increasing hostility to new mines and mine expansion. It has the second deepest open-pit mine in the world at a depth of 850 metres, and the environmental ramifications of ever-expanding Chilean mining is an intensely political issue.

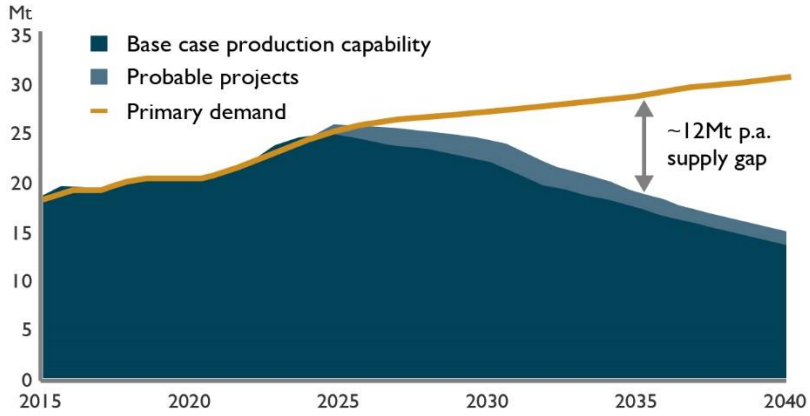
Annual Codelco Production Profile[6]



This supply constraint – in the world's leading producer country – is by no means unique. And it sets the stage for a supply constrained industry for many years ahead. Canadian copper producer Hudbay sees annual deficits of up to 12 million tonnes by the mid-2030s, as per the below chart:

[5] @JohnLeePettim13, (approx. 100 GJ/tonne. 1 gigajoule (GJ) = 26 litres of gasoline, or 278 kWh of electricity. Making 1 tonne of copper = 260 litres of gasoline or 27800kWh of electricity)
[6] Codelco

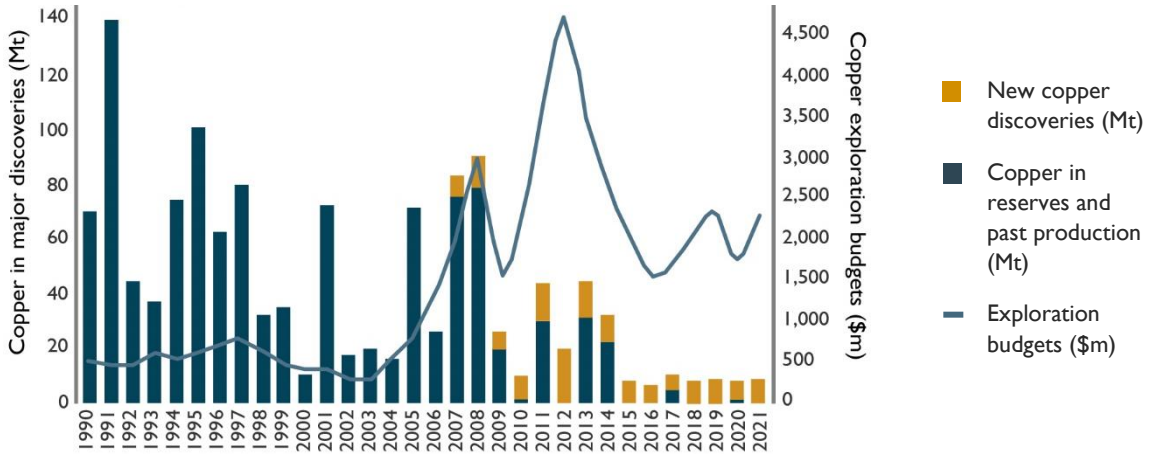
Global Copper Supply and Demand[7]



Listed mining companies have under-invested

Whilst there are multiple factors at work, a capital cycle analysis shows the major listed mining companies have persistently under-invested in copper. There are a variety of reasons for this. Poor shareholder returns over the past two decades have seen capital expenditure budgets slashed across all major miners: total mining capex was around $165 billion in 2012 and has fallen to just $100 billion in 2021[8]. Second, the return on these exploration dollars in terms of new discoveries has fallen significantly, as the chart below shows. During the period from 1990 to 2008 copper exploration budgets averaged around $1 billion. Post-2008 this exploration capex has roughly doubled, but only a handful of new copper mines have been discovered, all in challenging geographies such as Mongolia and the Democratic Republic of the Congo. According to Bloomberg Intelligence, the average lead time from first discovery to first metal has increased by four years from previous cycles, to almost 14 years in 2021.

Major Copper Discoveries[9]

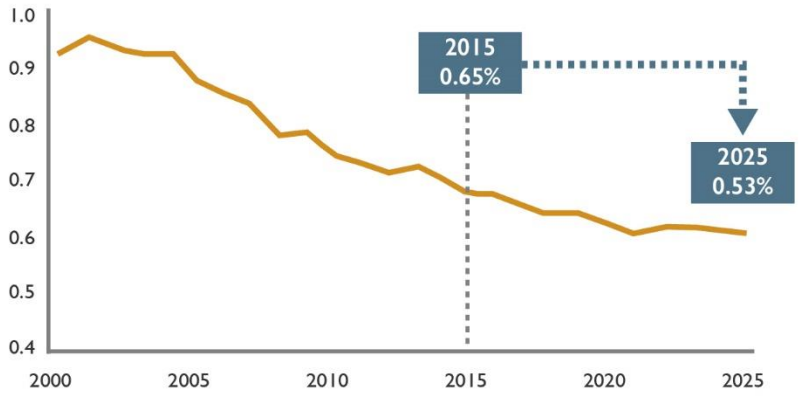


[7] Hudbay Investor Presentation January 2023, Wood Mackenzie, Copper Long-term Outlook Q4 2021

[8] S&P Global Market Intelligence
[9] S&P Global Market Intelligence

This supply outlook is compounded by the declining average grade, as the existing, aged mines are seeing ever lower grades as ore bodies are mined out. Under any sensible industry framework, the supply picture is bleak.

Declining Grade – Average Copper Ore Head Grades[10]



The looming imbalance

At Hosking Partners, we try to avoid making bets on demand forecasts. And demand forecasts related to the energy transition have become doubly untrustworthy, because they have become politicised. As Hosking Partners Head of ESG, Roman Cassini points out:

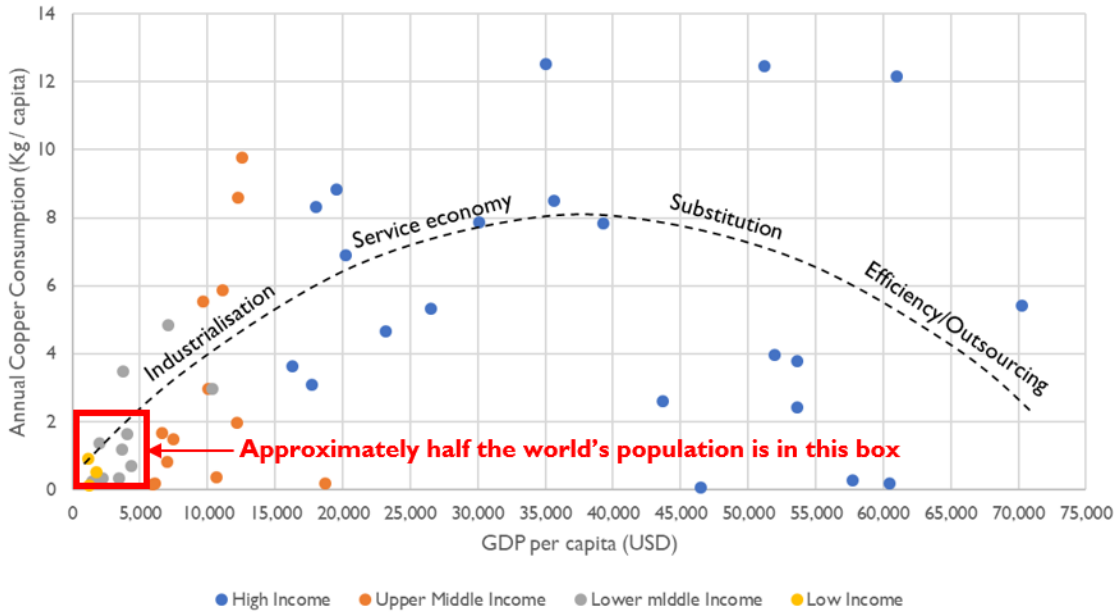
"If you draw a line in the sand and say, 'in order for the world to be net zero by this point, then X, Y and Z will need to have happened', and then forecast demand based on X, Y and Z happening, you have replaced forecasting with fatalism. The political imperative to frame the energy transition as a pathway from A to B misrepresents how the world really works. The journey to net zero is not a path, it is a maze. Accurately forecasting long-run demand in such a scenario is like trying to predict the fastest route out of the maze with a blindfold on."

Nevertheless, whilst we tend to avoid coming up with our own precise forecasts of economic or financial metrics, a directional appreciation of demand is implicit in our analysis of the capital cycle in supply. For copper the demand outlook is robust, relatively price inelastic, and has a large fan of outcomes. Firstly, copper usage is correlated with GDP growth. As the world's population grows, gross copper demand will rise. And as median GDP/capita grows, the intensity of that demand will increase, as low-income economies representing over half the world's population industrialise and electrify. Because the majority of the world's population is pre-industrial, this effect outweighs the lower usage intensities enjoyed by some of the world's richest societies. And as the diagram below depicts, the strongest increases in copper usage intensity come in the earlier stages of GDP per

[10] Mining.com

capital growth. Simple modelling suggests that base copper demand – excluding that pulled by energy transition-related themes in automobiles, renewables, and power transmission – will grow at a compound annual growth rate (CAGR) of 2-3% between now and 2050.

Copper consumption per capita vs GDP per capita[11]



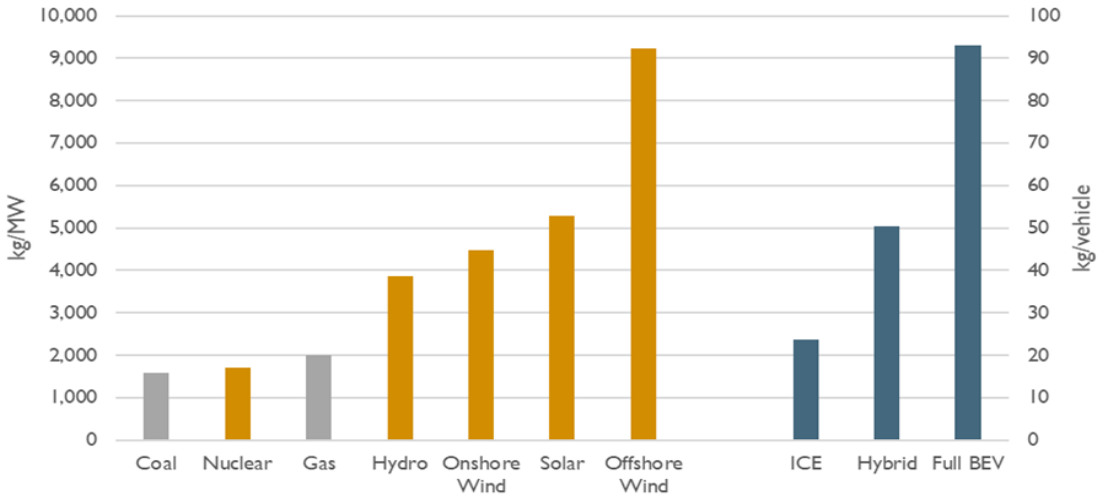
Second, as a critical metal for the energy transition, the potential upside scenarios for copper demand are vast. We do not claim to know exactly what this transition will look like, but three trends already appear well-established: (1) the rise of EVs; (2) the shift towards renewables; and (3) broader electrification facilitated by a massive build-out of power transmission and distribution. All three of these trends pull heavily on copper. EVs require 2-3x more copper than ICEs, and renewables require 2-5x more copper per MW of installed capacity than gas or coal. Meanwhile, power transmission is a two-metal game: copper and aluminium. Almost one third of the world's total copper demand is currently associated with one form or another of electrical wiring. Energy strategist Thunder Said Energy predicts that from now until 2050, annual growth in copper demand from these three trends are 9%, 5.2%, and 5.6% respectively[12].

The demand picture may be even more extreme in the medium term. If governments make a realistic effort to meet their stated (legally binding?) decarbonisation targets, then the ramp up in these themes is front-loaded. Copper demand growth from power and renewables to 2035 would be twice as high as the 2050 figures stated above. The picture for EVs is most extraordinary. In simple terms, if all the governments that have announced EV adoption targets hit them, the CAGR for EV-

[11] World Copper Factbook 2022, World Bank
[12] Thunder Said Energy

associated copper demand to 2035 is 26%, describing an 18x annual increase from 0.3 million tonnes in 2022 to 6 million tonnes in 2035.

Copper intensity of energy sources and automobiles[13]



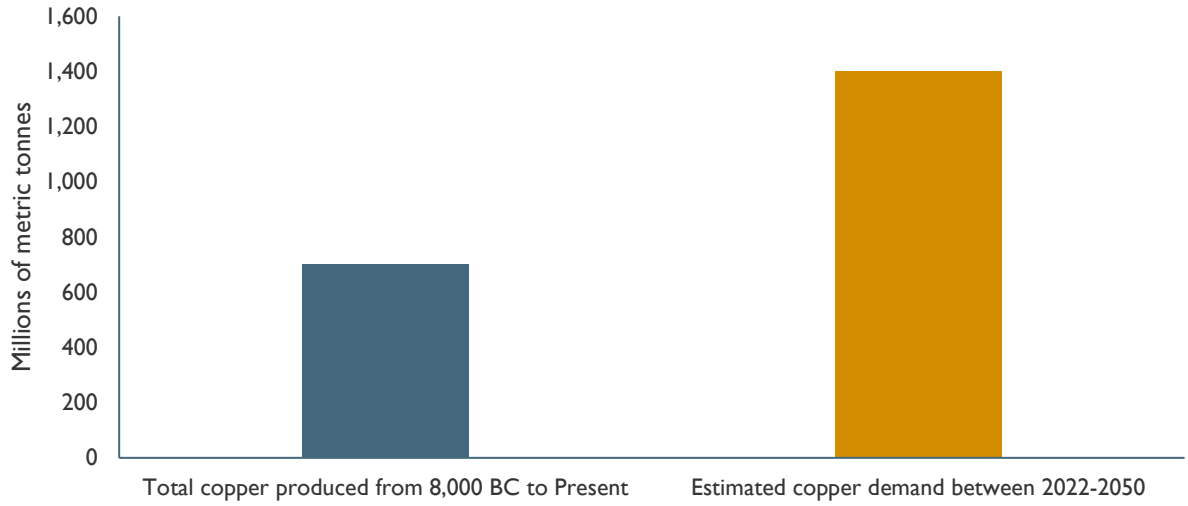
This front-loaded demand pull is important, because of the lead time required to expand mined copper production, which, as we discussed, has seen low returns from already depleted exploration budgets. One recent expert publication[14] modelled the expected market shortfall of refined copper at 20% (around 6-7 million tonnes, approximately half that of the Hudbay forecast) between now and 2035, assuming a rapid electrification scenario consistent with the net zero transition. For context, the largest historic shortfall was 2.5% between 1994 and 2022, a period in which the copper price rose 5x from $0.7 per pound to $3.8 per pound.

Standing back and taking the big picture view

Using conservative assumptions including 3% annual global GDP growth, 40% of electricity from renewables and 67% EV penetration by 2050, models suggest we could require upwards of 1.4 billion tonnes of copper between now and 2050. This figure assumes a 40% reduction in overall copper intensity to reflect technological and efficiency progress. To put this in perspective, 1.4 billion tonnes is twice the total amount of copper ever mined to date[15].

[13] Thunder Said Energy
[14] S&P Global Market Intelligence
[15] USGS

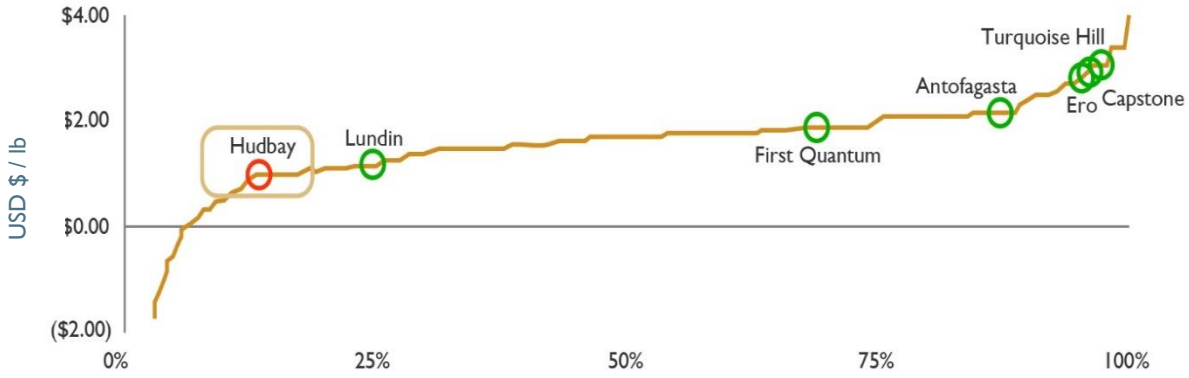
Copper produced to date versus estimated demand to 2025[16]



What could this mean for the copper price?

One of our investee companies recently posited that, in their view, the supply crunch in copper could see the price rise to $10 per pound before the end of the decade – a level that would incentivize additional production at hitherto uneconomic projects. At the current copper price of $4 per pound and industry copper costs of around $2.3 per pound at the 50% quartile of the cost curve as demonstrated in the below chart, this may seem far-fetched. However, this needs to be set against a net zero agenda – or should that be "electrification agenda" – that is equally aggressive.

Copper Cash Cost Curve[17]



As the saying goes, the best cure for high prices is high prices. Eventually, high prices will produce a supply response from copper mines (as well as from recycling and substitutions), and although it

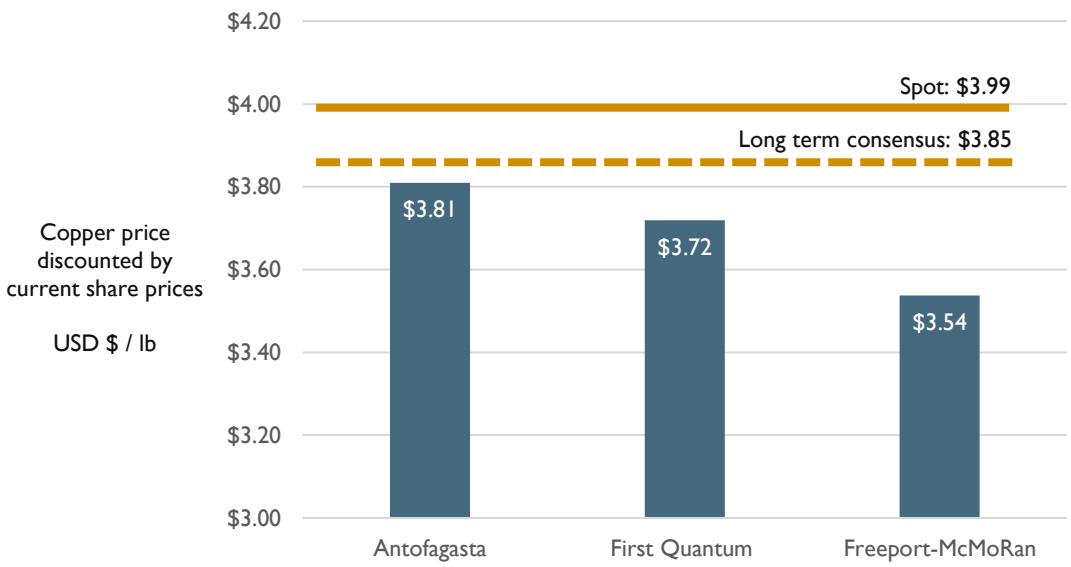
[16] USGS, Thunder Said Energy
[17] Source: Hudbay Investor Presentation, January 2023. Wood Mackenzie's 2023 by-product C1 + sustaining capex copper cost curve (Q4 2021 dataset dated December 2021). Wood Mackenzie's costing methodology may be different than the methodology reported by Hudbay or its peers in their public disclosure. For details regarding Hudbay's actual cash costs, refer to Hudbay's management's discussion and analysis for the 2021 fiscal year.

will take time for new supply to impact prices, returns will be impacted by increased capex before then. The timing of when this occurs, however, is further out than appears to be reflected in miners' share prices, whose low multiples imply today's returns will soon reverse. This time, however, there is strong reason to believe returns will be higher for longer (but just not forever): incentive programmes put in place after the last downturn make management better stewards of the balance sheet; local ESG makes permitting of new mines a much longer process than previously; climate change itself has led to more regulations around water use; and the carbon intensity of the miners' operations has raised their cost of capital.

What does this mean for the shares of copper miners?

There is a dynamic tension between the increasing scarcity of copper resource, demand for the commodity growing in line with GDP growth with an additional kicker from the energy transition, and copper miners' propensity to raise capex to chase attractive returns from increasing production. If these variables can be kept in overall equilibrium then there is an opportunity for the share prices of copper miners to erase the discount they currently show both to the spot price of copper and to long-term consensus estimates of the copper price, as illustrated in the chart below. A squeeze in the copper price beyond these levels is clear upside opportunity for the miners' shares.

Copper Miner Valuations vs Spot and Long-term Prices[18]



The basket approach

Our approach to the copper capital cycle is not to pick one single stock. Our basket of stocks – detailed in the appendix – represents just under 6% of the Hosking Partners global strategy and

[18] Datastream, BNP Paribas. Priced as of close 27th February 2023.

diversifies single-name risk whilst also exposing us to the select few copper companies that have managed to buck the declining industry and generate valuable supply growth. To put our basket in context: our most focused copper miners had a combined copper output of 4.4 million tonnes in 2021 (about 20% of global production) and they currently make around $24 billion EBITDA per year. Extrapolating this number implies total industry EBITDA of around $125 billion, equal to the 2022 EBITDA of Apple. This high-level comparison does not suggest to us an industry that is over-earning, particularly given the critical nature of copper to the climate transition process.

We are conscious that we operate in world which celebrates overly concentrated, single-stock bets. One in which a 20 stock-portfolio is seen as highly diversified. But this fetish for concentration has risks for asset owners, particularly in cyclical sectors. Any mining investment will see geology and politics play a critical role in determining long-term profitability. Copper mines are huge, immovable assets with potentially billions of dollars of sunk costs. As such, they are highly vulnerable to the actions of governments and local populations who bear the (enormous) immediate environmental consequences. Expropriations, punitive taxation, shut downs and other forms of fiscal harassment are relatively commonplace. A concentrated, one-stock approach to the copper cycle – or indeed any commodity investment – ignores this reality.

The primary insight here is constrained supply of capacity in the face of growing demand generating high returns. Across the globe, local-level opposition to copper mining has, paradoxically, increased just as demands for rapid de-carbonisation grow louder. In this sense, long-run copper returns are a double beneficiary of both ESG and the long-term climate transition agenda. When this is added to the primary capital cycle insight, that the sustained lack of capital investment in the sector should be positive for the direction of future returns for some time to come, rewards to patient shareholders should be substantial over the coming decade. The net zero movie has only just begun…

DJANGO DAVIDSON
March 2023

Appendix: List of Hosking Partners' Copper Investments and Portfolio Weights[19]

Company Name	Weight %
Anglo American plc	1.62
Freeport-McMoRan, Inc.	0.97
First Quantum Minerals Ltd.	0.83
Antofagasta plc	0.71
Rio Tinto plc	0.65
Glencore plc	0.34
Teck Resources Limited Class B	0.27
Gold Fields Limited	0.18
MMC Norilsk Nickel PJSC	0.16
Ivanhoe Mines Ltd. Class A	0.09
TOTAL	**5.82**

[19] Hosking Partners representative portfolio, weights as at 20 Feb 2023

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