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metal&ROCK

Long-term prices – stimulating supply

We have revised our long-term prices for metal and bulk commodities, using an incentive pricing methodology.

Long-term prices reviewed: We re-run our incentive price analysis for the key commodities, resulting in changes to our long-term price forecasts (2025 and beyond). The new forecasts (Exhibit 1) are incorporated into our latest price deck, which we also publish today (metal&ROCK: The Price Deck – 1Q 2019).

Incentive pricing methodology: We've reviewed our dataset of growth projects across the commodities, and compiled a subset of 145 representative projects, which are not yet under construction, but can reasonably be expected to be operational by 2025. We calculate the return on capital expenditure and operating expenditure for each asset, then weight the results using forecast annual production rates to generate the weighted average 'incentive price' required to bring that particular supply block to the market (assuming a 10% or 15% post-tax IRR). This becomes our long-term price forecast for that commodity.

Cost inflation: Upward cost pressures in 2018 have arisen from rising energy costs, raw materials prices and labour costs; as well as the growing cost of compliance with ever-tighter environmental legislation. Capex also continues to rise, although miners remain cautious and in our view it's unlikely to reach prior peaks over the coming years (see European Metals & Mining Tracker: Ding Dong). China's environmental policies continue to pose a risk to current cost estimates for China-based projects, with the cost of compliance adding upside risk to both capex and opex estimates, offset slightly by the trend towards new, more efficient facilities and growing supply in countries with lower cost bases.

Key changes: We have altered our methodology for **iron ore**, to account for the fact that the majority of unapproved projects in the pipeline will not be required, as seaborne iron ore demand moves ex-growth. We therefore expect future long-term prices to be determined by the marginal cost of production rather than incentive price, resulting in a 9% lift to our long-term price. For **thermal coal**, our analysis incorporates a higher required IRR – 15% rather than 10% – due to the difficulty obtaining financing for new coal mines, which we think will drive continued tightness in the market, despite a flat demand outlook. Firmer cost data for proposed new alumina refineries in Guinea have resulted in an 11.5% lift to our **alumina** incentive price assessment. Not all of our incentive prices have been revised higher, though; the inclusion of Tsingshan's HPAL nickel sulphate project in Indonesia brings down our average **nickel** incentive price assessment slightly from prior levels. Similarly, the inclusion of additional lower-cost **gold** and **metallurgical coal** projects has resulted in a modest downward revision to our incentive price assessment for these commodities.

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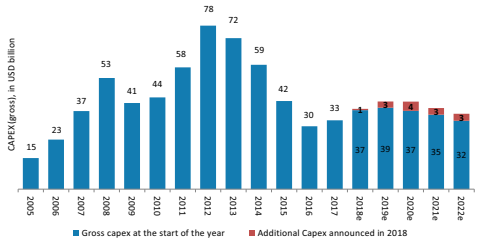
Exhibit 1: Morgan Stanley long-term prices, real 2018 US$

	US$/t; US$/oz	US$/lb	% chg vs real 2017
aluminium	$2,083	$0.95	+1.6%
alumina	$355		+8.2%
copper	$6,173	$2.80	+1.8%
nickel	$16,314	$7.40	-1.4%
zinc	$2,646	$1.05	+0.0%
gold	$1,140		-2.6%
Platinum	$1,112		-12.6%
Palladium	$1,011		+11.1%
iron ore (fines; seaborne)	$55		+10.0%
metallurgical coal (seaborne)	$124		-2.0%
thermal coal (seaborne)	$75		+7.8%

Source: Morgan Stanley Research estimates

Exhibit 2: Our capex estimates remain far below peak levels



Source: Company Data, Morgan Stanley Research estimates (e)

Results

Exhibit 3: Comparison of incentive pricing with alternative long-term price assessment methods

commodity		Incentive price real 2018 $	Incentive price nominal 2025 $	Industry marginal cost + historical margin	Average price 1980-2017 (real 2018 $)
Aluminium	US$/t	2,083	2,377	2,214	2,702
Alumina	US$/t	355	405	406	347
Copper	US$/t	6,173	7,043	5,994	5,104
Nickel	US$/t	16,314	18,613	19,595	16,182
Zinc	US$/t	2,315	2,641	2,232	2,183
Gold	US$/oz	1,140	1,301	1,125	917
Platinum	US$/oz	1,112	1,269	NA	1,055
Iron ore (fines; seaborne)	US$/t	55	63	89	89
Metallurgical coal (seaborne)	US$/t	124	141	167	129
Thermal coal (seaborne)	US$/t	75	86	101	79

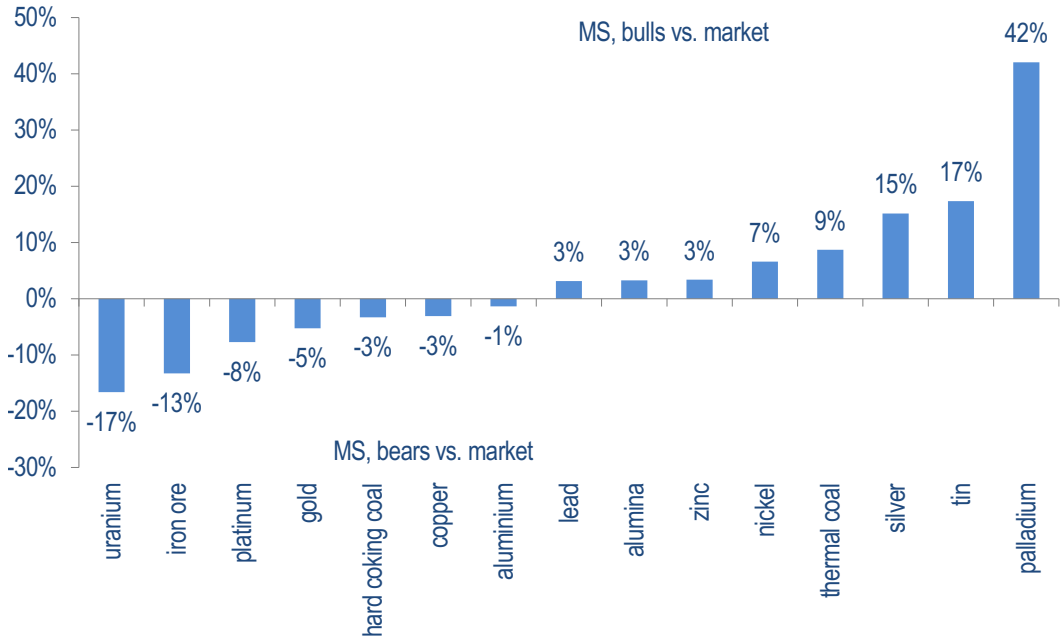
Source: Wood Mackenzie, company data, Morgan Stanley Research. NA = Not applicable

Exhibit 4: Summary of incentive price modelling results

			vs. current supply	Cash Costs (C1 Composite)		Estimated Project Capex			Sustaining Capex			IRR		LT Incentive Price (real 2018)		LT Incentive Price (nominal 2025)	
Commodity	Capacity	units	%	US¢/lb	US$/t; US$/oz	US$m	US¢/lb	US$/t; US$/oz	US$m	US¢/lb	US$/t; US$/oz	US¢/lb	US$/t	US¢/lb	US$/t; US$/oz	US¢/lb	US$/t; US$/oz
copper	2.31	Mtpa	10%	138	3032	39452	809	17835	1273	26	576	121	2675	280	6,173	319	7,043
aluminium	2.73	Mtpa	2%	76	1667	7347	122	2690	58	360	21	13	277	95	2,083	108	2,377
nickel	0.26	Mtpa	12%	396	8738	10222	1769	38999	498	86	1899	180	3958	740	16,314	844	18,613
zinc	2.17	Mtpa	16%	60	1333	11373	279	6153	196	5	106	28	615	105	2,315	120	2,641
gold	241	t	8%		637	23320		3013	556		72		301		1,140		1,301
PGMs (Pt equivalent)	3,033	oz			801			1,249			133		125		1,112		1,269
iron ore (fines; seaborne)	280	Mtpa	19%		33	22179		79	997		4		8		55		63
thermal coal (seaborne)	100	Mtpa	10%		59	5735		57	340		3		9		75		86
metallurgical coal (seaborne)	58	Mtpa	18%		100	100		5249	90		297		5		124		141

Source: Wood Mackenzie, Company Data, Morgan Stanley Research

Exhibit 5: Morgan Stanley vs consensus long-term price



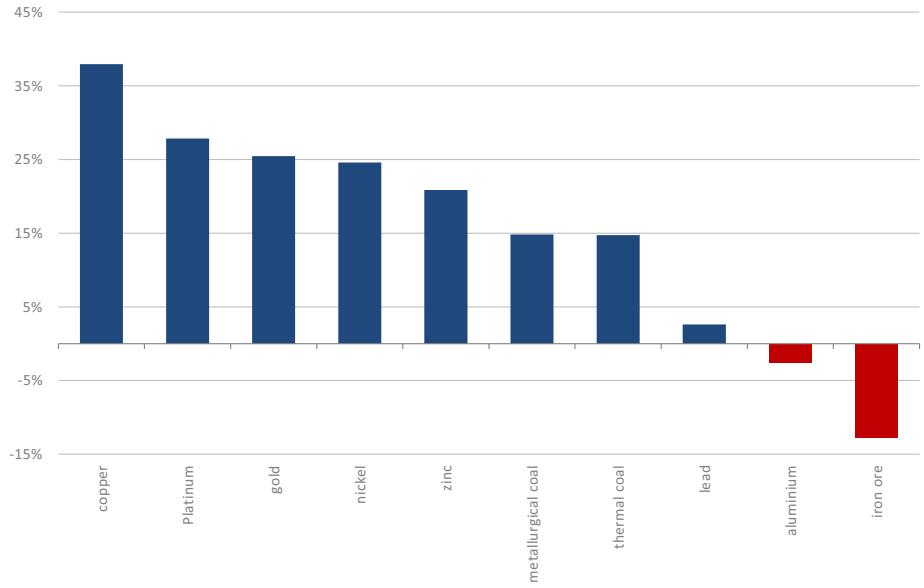
Source: Consensus Economics, Morgan Stanley Research estimates

Exhibit 6: MS commodity price forecasts + incentive price

commodity group	unit	2018	2019	2020	2021	2022	2023	2024	LT real	LT nom.
Aluminium	US$/lb	0.96	0.94	0.97	1.01	1.03	1.05	1.06	0.95	1.08
	US$/t	2113	2072	2127	2227	2271	2315	2346	2083	2377
Alumina	US$/t	471	375	343	348	350	392	400	355	405
Copper	US$/lb	2.96	3.09	2.96	2.90	3.04	3.10	3.15	2.80	3.19
	US$/t	6532	6801	6531	6393	6697	6834	6952	6173	7043
Nickel	US$/lb	5.92	5.31	6.40	7.51	7.80	8.18	8.33	7.40	8.44
	US$/t	13056	11712	14110	16562	17196	18023	18373	16314	18613
Zinc	US$/lb	1.33	1.14	1.00	1.08	1.14	1.16	1.18	1.05	1.20
	US$/t	2926	2513	2205	2370	2502	2557	2607	2315	2641
Lead	US$/lb	1.02	0.96	0.95	0.95	0.98	0.98	0.99	0.88	1.00
	US$/t	2245	2111	2094	2094	2161	2161	2191	1940	2213
Gold	US$/oz	1267	1295	1295	1290	1300	1300	1284	1140	1301
Platinum	US$/oz	885	815	863	962	1062	1162	1252	1112	1269
Palladium	US$/oz	1027	1240	1215	1205	1196	1189	1139	1011	1153
Iron Ore (fines 62% Fe, cfr N.China)	US$/t	69	62	58	60	60	60	62	55	63
Hard Coking Coal (prem. Cont., fob Aus)	US$/t	210	192	145	132	130	133	140	124	141
Thermal coal (spot, fob Newc)	US$/t	108	93	81	76	75	76	84	75	86

Source: Morgan Stanley Research estimates

Exhibit 7: Incentive price vs current industry marginal cost, 2018 $



Source: Wood Mackenzie, Morgan Stanley Research

Methodology

Incentive pricing approach

- We employ an **incentive pricing** methodology to determine long-term prices for the key commodities (from 2025). This approach closely reflects the producer community's investment decision-making process.
- We have reviewed our database of 500+ growth projects (greenfield; brownfield) across eight commodities, and calculated the economics of a subset of 145 viable, representative projects.
- We calculate the incentive price for each project from initial/sustaining capex and operating cost; then weight the results using forecast annual production rates of the assets.

Defining the 'long term': Industry standard (equity analysts and exploration/mining companies) generally regard time beyond the current business cycle (5-6 years) as the 'long term'. Our short-term price forecasts reflect this industry view – covering a rolling six-year period. Our long-term price forecast becomes active in our current price deck in 2025 (+7 years).

Supply-driven approach: The incentive pricing methodology assumes that, in the long run, supply will always rise to meet demand. Assuming demand continues to grow and/or as older assets exit the supply chain, the price of a commodity must rise to a level sufficient to attract new supply, providing miners/smelters with a reasonable return on their investment. The incentive price can be defined as:

A long-term commodity price that is sufficient to offset the capital costs necessary to finance a project that will produce that commodity, plus deliver an adequate return.

There are two different ways in which an incentive price can be calculated. We have adopted the most straightforward – using a **weighted average** of representative projects for any given commodity. The alternative is to assess the **supply gap**, i.e. the difference between supply and demand in a given year (2025, in our case) to determine exactly how much new supply is required. Projects can then be ranked by cost and timing – the last project needed to balance the market determines the incentive price. While this is an interesting exercise, it relies on many additional assumptions – long-run demand, precise project timings; as well as the inclusion of each potential new tonne in the market. We therefore consider the weighted average approach a more objective guide.

Project database: Our database of production, capex and cash cost of 155 proposed base metal, iron ore, and coal projects set to enter production within 7 years is compiled using a combination of Wood Mackenzie data, company reports, technical reports and feedback from our Global Mining team. For some commodities, where prices have been low for a sustained period, there are few projects on which to base our estimate. This is

particularly the case for the aluminium market today, and we acknowledge increased risk around our estimates for this market as a result.

Adjustments to our approach for 2018-19: This year, we've made two major changes to our approach. For **iron ore**, we have carried out the usual incentive price exercise, but given we see a market in substantial oversupply throughout the forecast period, we think a pure incentive price is inappropriate, and we set our long-term price in line with **marginal cost**. For **coal**, we have carried out the typical cash cost adjustments, but lifted the IRR to 15%, as discussed below.

Assessing the IRR: The IRR (unlevered, post-tax) assumed in the incentive pricing exercise is instrumental in determining the final outcome and therefore subject to debate. In the past, we have adopted an IRR of **10%** across all of the commodities in our assessment. This is a conservative value – many mining companies look for returns of around 15% when determining whether to proceed with an investment. However, we contend that, while 15% is desirable, not all projects over the long run will achieve this level of return. Furthermore, while many companies assess investments on a 15% IRR, they do not wait until the price has reached that level before approving the project, so we think a more conservative assessment is appropriate. We retain this methodology for base metals, PGMs and iron ore. However, for **coal** mining projects (both thermal + metallurgical) this year we have raised the IRR to **15%**. The investment climate for coal is particularly challenging due to sustainability concerns and we therefore take into consideration the fact that only those projects that can demonstrate a high rate of return will be able to obtain funding and proceed.

Alternative approaches: Two alternative methods used by industry analysts for setting long-term prices are: *industry marginal cost* analysis and *historical equilibrium price*:

- **Industry marginal cost:** Long-term prices are set to match the industry's current 9th decile of cash costs of production (i.e. above which only 10% of all production is delivered at a higher cost, or marginal cost). This is most useful for forecasting floor prices in surplus markets, when an incentive price is not required. This is the method we have used for our long-term iron ore price.

- **Historical equilibrium price:** This method uses historical real prices, costs & margins for a particular commodity's market and extrapolates to determine future trends. It is the simplest approach, but fails to take account of evolving technologies and/or new areas of supply that might fundamentally alter a market's cost of production.

Industry Trends

Operating cost pressure builds: High energy costs, rising labour costs and freight rates are all contributing to cost pressure on miners in 2018, which is expected to intensify over the coming years.

Capex restraint: Our equity analysts expect… capital expenditure to continue rising through 2019-20, although mining companies remain cautious given demand concerns. As a result, our colleagues expect mining capex to remain well below historical peaks across the sector.

Risks: The cost of compliance with China's environmental reform policies remains a key issue for its domestic mining/smelting industries, presenting ongoing upside risk to cost estimates for new supply. Import tariffs on raw materials and resource nationalism are additional sources of cost pressure.

Cost inflation

Exchange rates: Key commodity currencies depreciated vs the US dollar through 2018, providing some protection from broader cost inflation for miners. However, Morgan Stanley's FX analysts estimate that the US dollar is now overvalued by about 10-15%, and expect rising capital scarcity and funding costs to bring US dollar weakness in 2019 (see 2019 Global FX Outlook, 25 Nov 2018) – this is likely to bring growing cost pressure through the coming year.

Capital costs – sector restraint: Despite sector profits approaching peak levels in 2018, capex remains materially below previous highs, at around 1.3x depreciation, and corporates are maintaining a gradual approach to reinvestment, given demand concerns and recent price weakness. We therefore see no major shift in the approach to capital allocation – certainly for the large mining companies. A 10% increase to our Metals & Mining team's capex estimates for 2019-20 partly relates to higher maintenance spending or capex on acquired assets that will not drive additional volumes in the markets (see European Metals & Mining Tracker: Ding Dong, 22 Nov 2018).

Energy costs: Through much of 2018, a rising oil price added to broader cost pressure on miners, contributing to rising diesel, power and transport costs – with the heaviest impact on bulk producers. The 25-30% drop in headline crude oil prices in 4Q18, then, might have been expected to bring some relief. However, diesel, fuel oil and thermal coal prices have all remained at elevated levels, limiting the flow through to miners. Morgan Stanley's oil analysts expect continued strong growth in middle-distillate demand, and with the implementation of IMO 2020 regulations (read, 'freight'), little relief is expected in this segment of the oil market, both supporting a rebound in oil's price and maintaining cost pressure on miners. Morgan Stanley's oil analysts expect Brent crude to reach $67.5/bbl by mid-2019, before recovering to $75/bbl by 1H20 (see The Oil Manual: OPEC+: Back to Balance, 8 Dec 2018).

Freight rates: For the bulk materials producers, forthcoming changes in regulations pose a risk of higher costs. The International Maritime Organisation (IMO) requires all marine fuel to have a sulphur content below 0.5% by 2020 (from 3.5%). This could tighten shipping fundamentals and keep freight rates high, due to scrapping of older inefficient vessels; required scrubber paybacks; increasing low-sulphur fuel prices; and lower vessel speeds (see Sailing Toward the Harvest, 7 Nov 2018).

Labour costs: The lack of disruption due to strikes in Chile this year has come at the cost of higher wage rates and signing bonuses for new labour agreements at copper mines. Meanwhile, Rio Tinto partly attributed rising labour costs in Western Australia to an increase in capex for its Koodaideri iron ore project, citing increasing demand for skilled labour and contractors.

Raw materials costs: Raw materials cost pressures are easing – particulary with falling steel prices; and – for aluminium producers – a significant fall in alumina price, which we expect to continue into 2019. On the other hand, for base metals miners, lower gold, silver and cobalt prices have fed through into lower by-product credits.

Key risks

China's environmental policies: China's 'Blue Sky' policy has had far-reaching consequences across the metals and bulks markets. Broadly, stricter emissions limits, waste disposal controls and transport regulations are raising the cost of compliance for China's industry. Despite this year's slightly softer enforcement of winter pollution controls in the steel and aluminium industries, we see an ongoing impact from tougher legislation into the long term, driving mitigation, consolidation and/or relocation of plants/mines, and making it significantly more difficult to gain approval for new operations. Specific examples include the additional power tariff imposed on **aluminium** smelters with captive power supply; a ban on new **coal** mines in Shanxi province until 2020; a proposed ban on using diesel trucks for coal shipments; and ongoing disruption to **zinc/lead** mining as a result of frequent environmental inspections. The majority of these policies result in either reduced production (i.e. tighter markets) and/or higher costs in the near term, as well as adding to the incentive price needed for new projects in China. However, in the long run the drive towards new, more efficient plants and industry consolidation is likely to result in a decline in overall industry operating costs.

Trade protectionism: The imposition of import tariffs by the US, and counter-measures in China, have impacted a number of commodities and end-use products. While the majority of the impact is on downstream industry, of particular relevance here are tariffs imposed on raw materials such as alumina, which have added to the cost pressures on US aluminium smelters.

Resource nationalism: The DRC's new tax regime is the clearest example in 2018 of resource nationalism adding cost pressure, with the tax on copper production lifted to 3.5% (from 2.5%) and a 10% rate imposed on cobalt output. Higher taxes have also been proposed on mining in the Philippines, while governments in Mongolia, Panama and Indonesia have looked to raise taxes and/or stakes in local mines.

Aluminium & Alumina

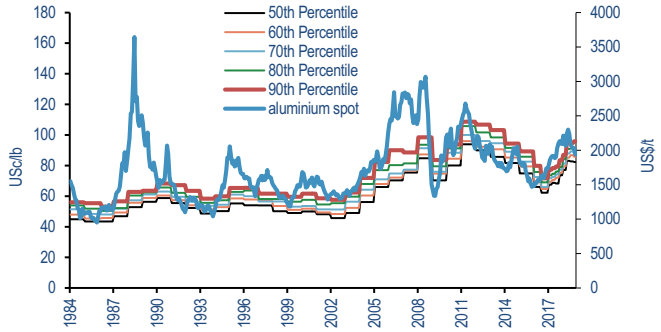
- Both **alumina** and **aluminium** are set to move into substantial deficit in the long-term, in the absence of significant investment in new smelters/refineries. However, a shortfall of fully-costed projects continues to make assessing an incentive price challenging.

- In **alumina**, new refineries are likely to be built in Guinea, where the current wave of investment in bauxite mining projects is set to be followed by refining plants, producing alumina for export to China. In addition to a potential expansion of the operating Friguia refinery, there are a further five refinery projects in Guinea totalling 7.7Mtpa. The recent $20 billion loan from China to Guinea to secure alumina underlines the country's interest in Guinea's bauxite reserves and guarantees the China Power Investment Corp's planned refinery. In the absence of full cost details for each of these projects, we use an indicative example in our analysis, implying an incentive price of around **US$355/t**. Ex-Guinea, new capacity is most likely to be added in China and India, with some potential for new supply from Indonesia, at a similar incentive price.

- In **aluminium**, most new capacity is expected to be brought online in the developing world. China's capacity swap programme means new capacity is being brought online to replace smelters closed on environmental grounds in recent years; while ex-China developments are likely in India, Russia and the Middle East. We continue to see a long-term incentive price sub-$2,100/t in real terms, at **US$2,083/t** (real 2018 $; +1.6% year on year).

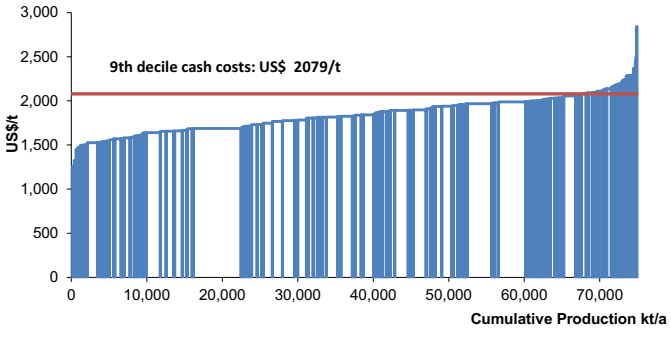
- While our list of representative projects does not imply sufficient capacity to fill the 5.8Mt gap between supply and demand for aluminium, there are many potential brownfield smelter expansions – particularly in China – that are likely to fill this gap, but which are not included in our analysis below.

Exhibit 8: Aluminium cost curve evolution



Source: Wood Mackenzie, company data, Morgan Stanley Research

Exhibit 9: Aluminium cost curve 2025 and long-term marginal cost



Source: Wood Mackenzie, company data, Morgan Stanley Research

Exhibit 10: Aluminium project list and incentive price model outcome

Project	Owner	Country	Startup Year	Type	Capacity tonnes	Cash Costs (C1 Composite) US¢/lb	Cash Costs (C1 Composite) US$/t	Estimated Project Capex US$m	Estimated Project Capex US¢/lb	Estimated Project Capex US$/t	Sustaining Capex US$m	Sustaining Capex US¢/lb	Sustaining Capex US$/t	IRR US¢/lb	IRR US$/t	LT Incentive Price US¢/lb	LT Incentive Price US$/t
TOTAL					**2,731,500**	**75.6**	**1,666.5**	**7,347**	**122**	**2,690**	**58**	**360**	**21**	**12.6**	**277**	**94.5**	**2,084**
Taishet	Rusal	Russia	2022	greenfield	428,500	75.0	1,654	1,772	188	4,135	15	384	35	19.3	426	**104.2**	**2,298**
Angul	Nalco	India	2022	brownfield	600,000	81.9	1,805	1,800	136	3,000	14	359	24	14.0	309	**103.0**	**2,270**
Asalouyeh	Salco	Iran	2022	greenfield	300,000	54.4	1,200	1,200	181	4,000	10	378	33	18.7	412	**82.6**	**1,822**
TALCO-Yunnan	Tursunzade II	Tajikstan	2020	brownfield	503,000	76.9	1,696	1,600	144	3,181	12	340	24	14.9	328	**99.2**	**2,188**
Yunnan Shenhuo	Yunnan Shenhuo	China - Yunnan	2022	greenfield	900,000	78.0	1,719	975	49	1,083	7	326	8	5.1	112	**85.6**	**1,886**

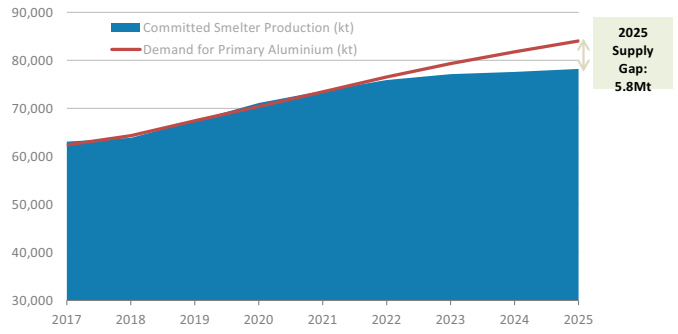
Source: Company data, Wood Mackenzie, Morgan Stanley Research

Exhibit 11: Alumina project list and incentive price model outcome

Project	Owner	Country	Startup Year	Type	Capacity tonnes	Cash Costs (C1 Composite) US¢/lb	Cash Costs (C1 Composite) US$/t	Estimated Project Capex US$m	Estimated Project Capex US¢/lb	Estimated Project Capex US$/t	Sustaining Capex US$m	Sustaining Capex US¢/lb	Sustaining Capex US$/t	IRR US¢/lb	IRR US$/t	LT Incentive Price US¢/lb	LT Incentive Price US$/t
TOTAL					**7,916**		**258.3**	**3,307**		**418**	**53**		**6.6**		**62.7**		**354**
Lanjigarh	Vedanta	India	2021	brownfield	4,000		271.3	1,570		393	18.0		4.5		58.9		**360**
Damanjodi Ph 3	Nalco	India	2021	brownfield	1,000		182.9	847		847	11.6		11.6		127.1		**376**
Zhongzhou	Chalco	China	2021	brownfield	916		286.8	55		60	15.0		16.4		9.0		**316**
Guangxi Fangchenggang	Chalco	China	2020	greenfield	2,000		257.0	835		418	8.0		4.0		62.6		**350**
Guinea refinery	Guinea refinery	Guinea	2022	greenfield	1,000		180.0	800		800	4.0		4.0		120.0		**355**

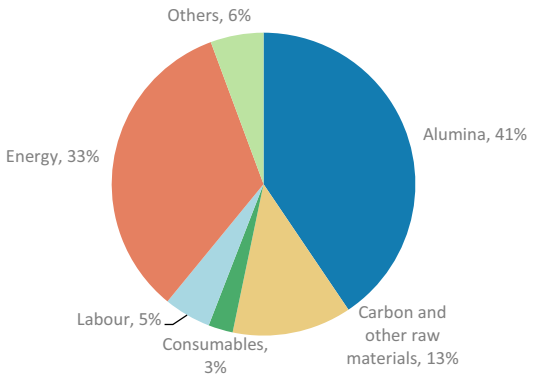
Source: Company data, Wood Mackenzie, Morgan Stanley Research

Exhibit 12: Aluminium supply gap, 2025



Source: Morgan Stanley Research

Exhibit 13: Aluminium cash costs by component



Source: Wood Mackenzie

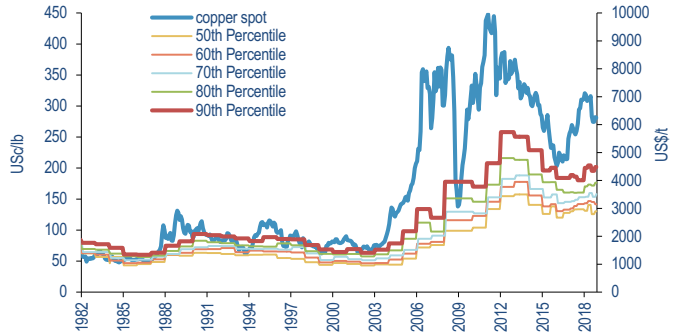
Copper

- A host of copper mine project approvals during 2018 (including Mina Justa, Quellaveco, Salobo III, Los Pelambres expansion, Quebrada Blanca II) have narrowed the long-term gap between supply and demand to 1.1Mt by 2025 (our estimate). We exclude fully approved projects from our analysis, as cancellations are unlikely unless price falls towards cost-support levels. Further investment is still needed, though, to offset attrition at existing mines and ensure the market remains balanced.

- Based on our analysis of 27 mine projects, totalling 2.3Mtpa of potential new supply, **we raise our forecast long-term copper price by 1.8% to US$2.80/lb** (real 2018 US$ terms). Upside risk to our estimate stems from upward revisions to published capital cost estimates, as well as the demand for higher rates of return. Using a 15% IRR rather than our base case of 10% implies an incentive price of US$3.37/lb. However, as this year's approvals demonstrate, projects are frequently signed off at a lower copper price than initial incentive price estimates suggest is required.

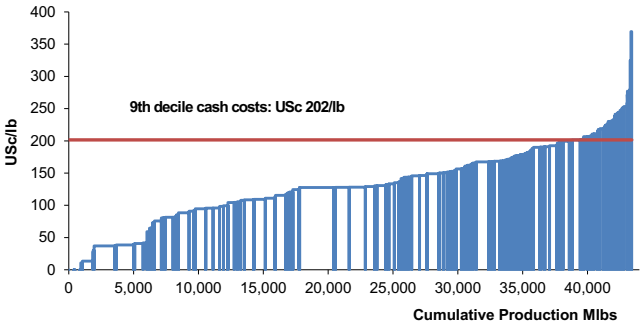
- Although copper has the longest project list of any of the commodities under our coverage, few are at an advanced stage, and the significant challenges and long lead-times to development of greenfield copper mines will likely result in delays or even cancellations of several of the projects in our database. However, additional mine life extensions and brownfield investments, which aren't currently included in our analysis, are also likely to emerge, helping to balance the market through the medium term.

Exhibit 14: Copper cost curve evolution



Source: Wood Mackenzie, company data, Morgan Stanley Research

Exhibit 15: Copper cost curve 2025 and long-term marginal cost



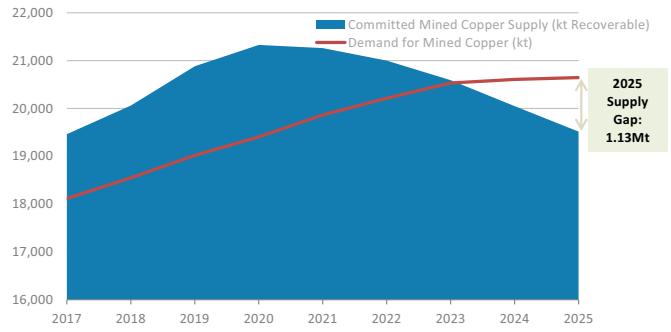
Source: Wood Mackenzie, company data, Morgan Stanley Research

Exhibit 16: Copper incentive price data

Project	Owner/Operator	Country	Potential Startup	Type	Annual output	Payable metal	Cash Costs (C1 Composite)		Estimated Project Capex			Sustaining Capex			IRR		LT Incentive Price	
			Year		tonnes Cu	tonnes Cu	US¢/lb	US$/t	US$m	US¢/lb	US$/t	US$m	US¢/lb	US$/t	US¢/lb	US$/t	US¢/lb	US$/t
TOTAL					**2,306,134**	**2,212,089**	**138**	**3,032**	**39,452**	**809**	**17,835**	**1,273**	**26.1**	**576**	**121.3**	**2,675**	**337**	**7,429**
Andina Exp	Codelco	Chile	2025	brownfield	160,000	154,400	140	3,086	3,250	921	20,313	230	65	1,438	138.2	3,047	**403**	**8,877**
Antilla	Panoro Minerals	Peru	2024	greenfield	21,861	20,987	163	3,594	250	520	11,454	15	31	689	77.9	1,718	**306**	**6,737**
Bahuerachi	Jinchuan	Mexico	2022	greenfield	75,214	72,581	157	3,461	1,304	786	17,337	17	10	230	118.0	2,601	**336**	**7,406**
Baimskaya	Kaz Minerals	Russia	2027	greenfield	255,000	246,075	90	1,984	5,048	898	19,796	350	62	1,373	134.7	2,969	**345**	**7,599**
Carmacks	Copper North Mining	Canada	2021	greenfield	11,900	11,484	108	2,381	195	743	16,387	16	61	1,345	111.5	2,458	**328**	**7,237**
Constellation	NGEx Resources	Argentina	2024	greenfield	150,000	144,750	105	2,315	3,080	931	20,533	91	28	607	139.7	3,080	**332**	**7,322**
Cotabambas	Panoro Minerals	Peru	2025	greenfield	70,500	68,033	164	3,616	1,530	984	21,702	16	10	230	147.7	3,255	**385**	**8,496**
El Arco	Southern Copper	Mexico	2023	greenfield	190,000	183,350	150	3,307	2,400	573	12,632	34	8	176	85.9	1,895	**281**	**6,190**
Eva Copper Project	Copper Mountain Mining Corporation	Australia	2023	greenfield	41,005	38,134	174	3,836	350	387	8,536	2	2	55	58.1	1,280	**259**	**5,720**
Galeno	Minmetals/Jiangxi	Peru	2024	greenfield	90,000	86,850	123	2,712	3,500	1,764	38,889	40	20	444	264.6	5,833	**521**	**11,489**
Hillside	Rex Minerals	Australia	2021	greenfield	35,000	33,775	219	4,828	381	494	10,884	9	11	252	74.1	1,633	**336**	**7,412**
Ilovica-Shtuka	Euromax Resources	Macedonia	2021	greenfield	16,800	16,212	205	4,519	474	1,281	28,232	11	30	655	192.1	4,235	**509**	**11,224**
Kamoa-Kakula (6Mtpa)	Ivanhoe Mines	Congo D.R.	2024	greenfield	145,000	139,925	151	3,329	1,352	423	9,324	51	16	354	63.4	1,399	**258**	**5,681**
Kemess UG	Centerra Gold	Canada	2022	brownfield	21,318	20,572	128	2,822	457	972	21,437	16	35	762	145.9	3,216	**371**	**8,178**
Kudz ze Kayah	BMC Minerals	Canada	2021	greenfield	13,920	13,433	126	2,778	350	1,140	25,144	13	42	934	171.1	3,772	**413**	**9,100**
Magistral	Nexa Resources	Peru	2022	greenfield	45,225	43,642	109	2,403	555	557	12,275	9	9	199	83.5	1,841	**237**	**5,232**
Michiquillay	Southern Copper	Peru	2025	greenfield	225,000	217,125	135	2,976	2,500	504	11,111	32	6	142	75.6	1,667	**249**	**5,499**
Morrison Project	Pacific Booker Minerals	Canada	2022	greenfield	29,592	28,556	160	3,527	407	625	13,768	17	26	574	93.7	2,065	**320**	**7,052**
Northmet Phase I	PolyMet Mining	USA	2020	greenfield	54,800	41,096	191	4,211	945	782	17,245	11	9.1	202	117.3	2,587	**368**	**8,108**
Pukaqaqa	Nexa Resources	Peru	2025	greenfield	40,000	38,600	195	4,299	706	801	17,650	10	11	238	120.1	2,648	**377**	**8,319**
Rajo Inca	Codelco	Chile	2021	brownfield	80,000	77,200	208	4,586	800	454	10,000	50	28	625	68.0	1,500	**334**	**7,353**
Rosemont	Hudbay Minerals	USA	2021	greenfield	112,000	108,080	130	2,866	1,921	778	17,152	61	25	545	116.7	2,573	**321**	**7,086**
Santo Domingo Sur Iris	Capstone Mining Corp.	Chile	2022	greenfield	58,000	55,970	128	2,826	1,771	1,385	30,538	21	16	356	207.8	4,581	**441**	**9,726**
Stockman	CopperChem Ltd	Australia	2022	brownfield	26,000	25,090	214	4,718	350	611	13,462	7	11	251	91.6	2,019	**356**	**7,853**
Tia Maria SxEw	Southern Copper	Peru	2022	greenfield	120,000	115,800	148	3,263	1,400	529	11,667	13	5	110	79.4	1,750	**266**	**5,873**
Twin Metals	Twin Metals (Antofagasta)	USA	2023	greenfield	88,000	84,920	76	1,676	2,775	1,430	31,533	88	45	1,000	214.5	4,730	**428**	**9,432**
Udokan Project	Baikal Mining	Russia	2025	greenfield	130,000	125,450	133.8	2,950	1,400	488	10,769	43.8	15.3	337	73.3	1,615	**254**	**5,594**

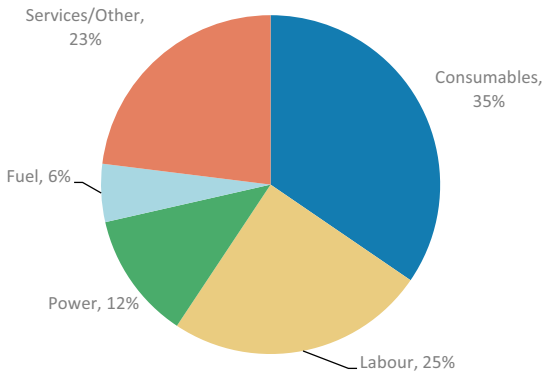
Source: Company data, Wood Mackenzie, Morgan Stanley Research

Exhibit 17: Copper supply gap, 2025



Source: Morgan Stanley Research

Exhibit 18: Copper mine costs, by component

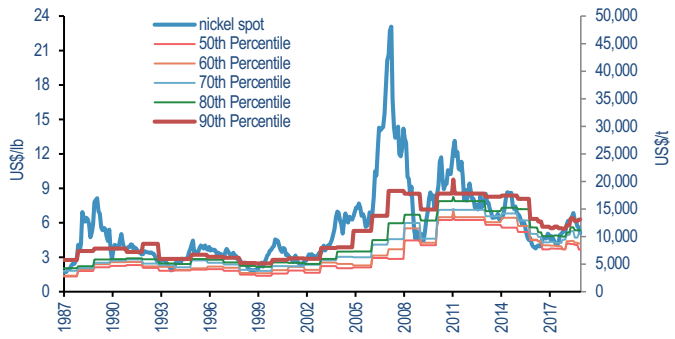


Source: Wood Mackenzie

Nickel

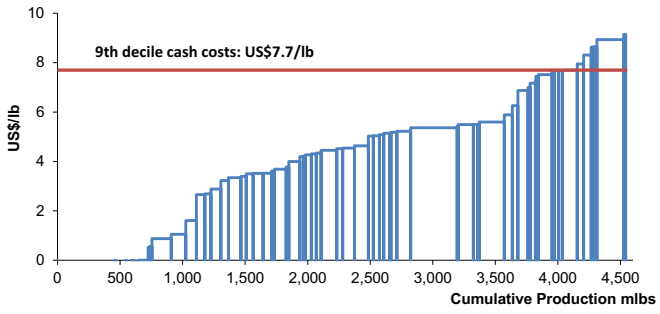
- Nickel's price remains well below incentive levels and, as a result, there is little change to our list of representative mine projects vs 2017, which includes 13 projects totalling 262ktpa of potential supply.
- The addition of Tsingshan's HPAL project, set to produce nickel sulphate for the battery market, has raised questions about the potential for further, similar projects using low-grade Indonesian ore at a low incentive price. While full cost data for Tsingshan's plant are not yet available, we use indicative estimates, which imply an incentive level in the $12-13k/t range.
- Despite the addition of Tsingshan, over the forecast period to 2025 we continue to see a need for additional nickel mine developments ex-Indonesia at higher incentive prices – with the most likely candidates for development in Canada and Australia.
- As a result of the inclusion of Tsingshan, **we lower our long-term nickel price 1.4% to $16,314/t ($7.40/lb)**.

Exhibit 19: Nickel cost curve evolution



Source: Wood Mackenzie, company data, Morgan Stanley Research

Exhibit 20: Nickel cost curve 2025 and long-term marginal cost



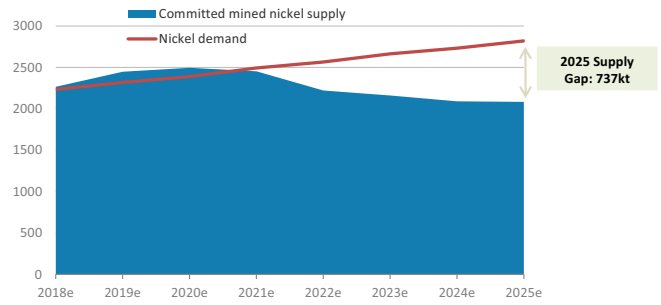
Source: Wood Mackenzie, company data, Morgan Stanley Research

Exhibit 21: Nickel project list and incentive price model outcome

Project	Owner	Country	Product	Startup	Type	Process	Capacity	Cash Costs (C1 Composite)		Estimated Project Capex			Sustaining Capex			IRR		LT Incentive Price	
				Year			tonnes	US¢/lb	US$/t	US$m	US¢/lb	US$/t	US$m	US¢/lb	US$/t	US¢/lb	US$/t	US¢/lb	US$/t
TOTAL							**262,112**	**396**	**8,738**	**10,222**	**1,769**	**38,999**	**498**	**86**	**1,899**	**179.6**	**3,958**	**739**	**16,292**
Araguaia	Horizonte Minerals	Brazil	Laterite	2020	greenfield	FeNi (RKEF)	14,500	315	6,948	443	1,386	30,557	50	155	3,414	140.7	3,102	**671**	**14,793**
Dumont	RNC	Canada	Sulphide	2022	greenfield	Mine	33,000	338	7,452	1,718	2,361	52,061	37	51	1,121	239.7	5,284	**731**	**16,122**
Eagle's Nest	Noront Resources	Canada	Sulphide	2024	greenfield	Mine	19,600	347	7,650	477	1,104	24,337	160	370	8,163	112.0	2,470	**877**	**19,342**
Fisher East	Rox Resources	Australia	Sulphide	2020	greenfield	Mine	7,300	419	9,237	62	383	8,438	26.80	167	3,671	38.8	856	**641**	**14,132**
Kun-Manie	Amur Minerals	Russia	Sulphide	2024	greenfield	Mine	27,000	593	13,073	336	564	12,444	66	111	2,444	57.3	1,263	**786**	**17,322**
Lucky Break	Pacific American Coal	Australia	Laterite	2022	greenfield	Heap Leach	800	516	11,377	15	850	18,750	1	57	1,250	86.3	1,903	**696**	**15,346**
Makwa	Grid Metals	Canada	Sulphide	2021	greenfield	Mine	9,293	595	13,117	164	798	17,597	5	25	560	81.0	1,786	**736**	**16,228**
NiWest	GME Resources	Australia	Laterite	2022	greenfield	Heap Leach	16,889	320	7,055	966	2,594	57,197	7	18	400	263.3	5,806	**714**	**15,748**
Syerston	CleanTeq	Australia	Laterite	2020	greenfield	PAL	18,730	295	6,504	680	1,647	36,305	22	53	1,175	167.1	3,685	**587**	**12,942**
Tsingshan	Tsingshan	Indonesia	Laterite	2019	greenfield	PAL	20,000	318	7,000	700	1,588	35,000	7	16	350	161.1	3,553	**564**	**12,425**
Turnagain	GigaMetals	Canada	Sulphide	2024	greenfield	Mine	35,000	426	9,392	1,454	1,884	41,543	73	95	2,086	191.3	4,217	**794**	**17,501**
Wingellina	Metals X	Australia	Laterite	2023	greenfield	PAL	40,000	334	7,363	2,500	2,835	62,500	42	48	1,050	287.7	6,344	**793**	**17,476**
Zebediela	URU Metals	South Africa	Sulphide	2022	greenfield	Mine	20,000	540	11,905	708	1,606	35,400	1	3	74	163.0	3,593	**776**	**17,112**

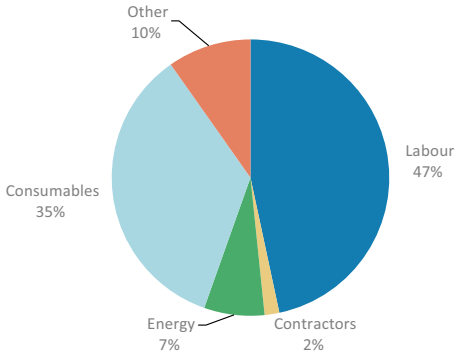
Source: Company data, Wood Mackenzie, Morgan Stanley Research

Exhibit 22: Nickel supply gap 2025



Source: Morgan Stanley Research

Exhibit 23: Nickel sulphide cash cost by component

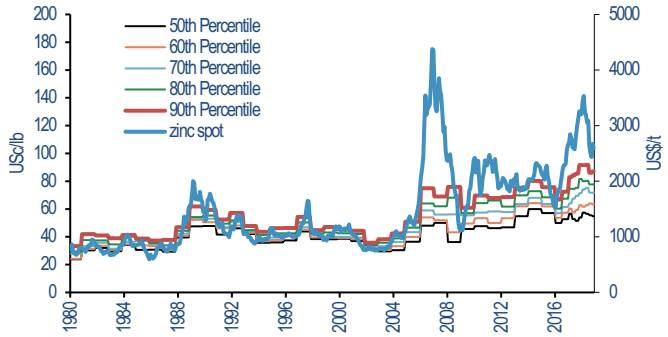


Source: Wood Mackenzie

Zinc

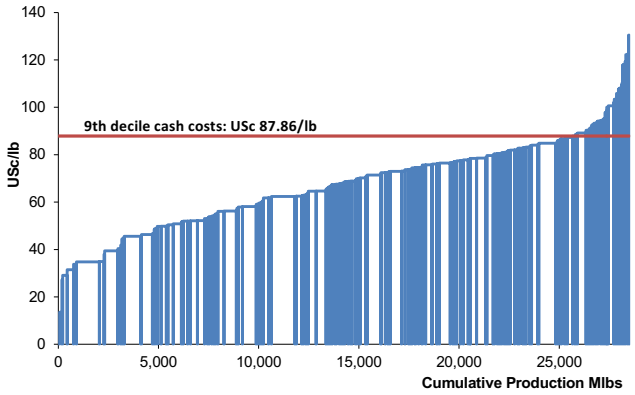
- Three major mine projects brought into production in 2018 – Dugald River, Century Tailing and Gamsberg – have returned zinc's concentrate market to balance, negating the need for an incentive price through the medium term, and suggesting a likely return of zinc's price to cost support levels.
- China's domestic mine supply remains a key uncertainty. As much as 35% of global mine supply is in China, but miners have faced considerable environmental scrutiny over the past year that has constrained production growth. Consolidation of China's mining sector is taking place, and we expect a resumption of supply growth from larger operations in the medium term, but little of this can be considered fully committed.
- **We maintain our long-term zinc price at US$1.05/lb ($2,315t)**, based on our sample list of 17 representative zinc projects, ex-China, totalling a potential 2.2Mt of new supply.
- Our long-term **lead** price also remains unchanged at US$1,940/t ($88/lb).

Exhibit 24: Zinc cost curve evolution



Source: Wood Mackenzie, company data, Morgan Stanley Research

Exhibit 25: Zinc cost curve 2025 and long-term marginal cost



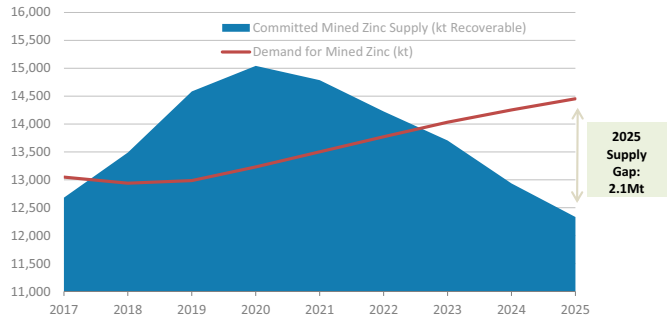
Source: Wood Mackenzie, company data, Morgan Stanley Research

Exhibit 26: Zinc project list and incentive price model outcome

Project	Owner	Country	Startup	Type	Capacity	Payable metal	Cash Costs (C1 Composite)		Estimated Project Capex			Sustaining Capex			IRR		LT Incentive Price	
			Year		tonnes	tonnes	US¢/lb	US$/t	US$m	US¢/lb	US$/t	US$m	US¢/lb	US$/t	US¢/lb	US$/t	US¢/lb	US$/t
TOTAL					**2,174,609**	**1,848,418**	**60.5**	**1,333**	**11,373**	**279**	**6,153**	**196**	**5**	**106**	**27.9**	**615**	**105**	**2,318**
Asmara	SRBM	Eritrea	2021	greenfield	65,000	55,250	41.9	925	681	476	10,483	4	3	60	47.6	1,048	**113**	**2,482**
Back Forty	Aquila Resources Inc	USA	2022	greenfield	91,481	77,759	46.0	1,014	294	146	3,214	16	8	173	14.6	321	**75**	**1,646**
Bahuerachi	Jinchuan	Mexico	2022	greenfield	366,000	311,100	72.5	1,598	1,409	175	3,850	15	2	42	17.5	385	**99**	**2,190**
Buenavista	Grupo Mexico	Mexico	2021	greenfield	80,000	68,000	80.3	1,770	413	234	5,163	13	8	166	23.4	516	**121**	**2,674**
Citronen Project	Ironbark Zinc	Greenland	2021	greenfield	177,000	150,450	66.0	1,455	514	132	2,905	7	2	40	13.2	291	**87**	**1,910**
Izok Lake Project	MMG	Canada	2023	greenfield	237,000	201,450	68.3	1,506	1,929	369	8,139	22	4	91	36.9	814	**125**	**2,759**
Kipushi restart	Ivanhoe Mines	DRC	2020	brownfield	225,000	191,250	48.0	1,058	337	68	1,498	12	2	53	6.8	150	**60**	**1,325**
Kudz ze Kayah	BMC Minerals	Canada	2024	greenfield	95,150	80,878	70.6	1,556	298	142	3,129	12	6	125	14.2	313	**97**	**2,128**
Mehdiabad	Karoun Dez Dasht	Iran	2021	greenfield	177,000	150,450	42.2	930	2,614	670	14,768	11	3	62	67.0	1,477	**141**	**3,102**
Ozernoe	MBC Resources	Russian Federation	2024	greenfield	231,800	197,030	43.0	948	1,330	260	5,738	15	3	63	26.0	574	**83**	**1,830**
Pilbara (Sulphur Springs)	Venturex Resources	Australia	2021	greenfield	39,749	33,786	14.0	309	122	139	3,061	15	17	377	13.9	306	**51**	**1,123**
Pine Point Restart	Pine Point Mining	Canada	2021	brownfield	66,600	56,610	77.4	1,706	120	82	1,806	7	5	106	8.2	181	**94**	**2,071**
Prairie Creek	Canadian Zinc	Canada	2022	greenfield	43,000	36,550	75.0	1,653	218	230	5,076	8	8	181	23.0	508	**116**	**2,560**
Selwyn	Selwyn Chihong Mining	Canada	2022	greenfield	55,500	47,175	80.4	1,773	319	261	5,748	24	19	426	26.1	575	**137**	**3,019**
Stockman Project	CopperChem Ltd	Australia	2021	greenfield	89,800	76,330	85.0	1,874	203	103	2,261	7	3	73	10.3	226	**103**	**2,269**
Tala Hamza (Oued Amizour)	Terramin	Algeria	2022	greenfield	69,529	59,100	53.0	1,168	341	222	4,904	7	4	99	22.2	490	**89**	**1,968**
Yenipazar	Aldridge Minerals	Turkey	2022	greenfield	65,000	55,250	62.8	1,385	230	161	3,538	3	2	47	16.1	354	**88**	**1,937**

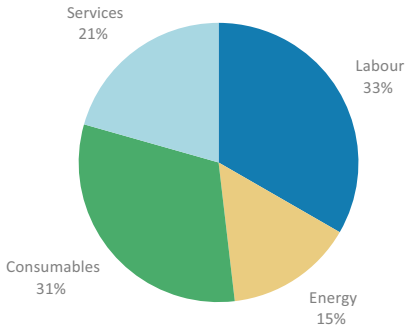
Source: Company data, Wood Mackenzie, Morgan Stanley Research

Exhibit 27: Zinc supply gap, 2025



Source: Morgan Stanley Research

Exhibit 28: Zinc cash costs by component



Source: Wood Mackenzie

Gold & PGMs

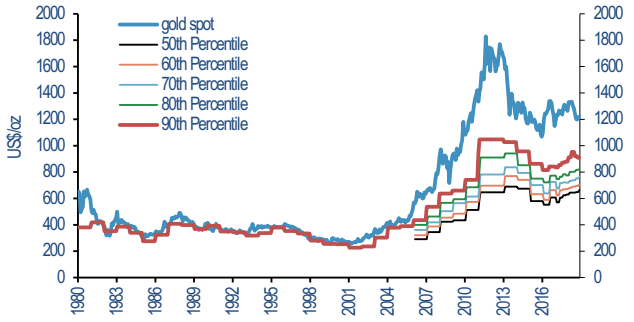
- General cost inflation and lower by-product prices have put upward cost pressure on **gold** miners in 2018, partly countered by rising yields and reductions to sustaining capex. Based on our sample of 32 gold-mine projects, with total potential output of 241tpa, **we lower our long-term gold price by 3% to $1,140/oz.**

- We set **PGM** incentive prices with reference to the basket of PGMs – they are mined together, and are substitutable to a degree in their major industrial application, autocatalytic emission control. In determining the USD prices by metal, two other inputs are key: 1. an assumed long-term real ZAR/USD of 14.50; and 2. long-term substitution ratio between metals. We use a Pt:Pd ratio of 1.1x (assuming the substitution ratio is ~1x in gasolines and ~1.5x in diesels) and Rh:Pd of 3x.

- We include 5 PGM projects in our incentive price study, 3 currently in ramp-up phase and 2 that we see as highly likely over the next 4-5 years. Together, we expect these projects to contribute incremental production amounting to 15%/20%/7% of 2018 global Pt/Pd/Rh supply. In general, these projects look to grow production at the bottom of the cost curve; however, they may not be fully able to replace the fall-off in the existing supply base over the next 5 years (for rhodium in particular). Furthermore, we assume that none of these projects requires additional capital-intensive smelting or refining capacity. As such, they are likely conservative.

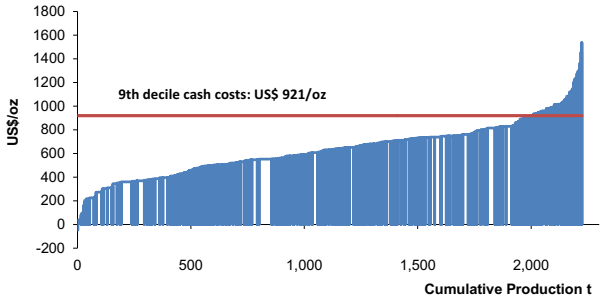
- Based on our sample of 5 PGM projects, we lift our USD basket price by 1.5% in USD terms and 5% in ZAR terms – a level broadly commensurate with annual inflation. **We cut our long-term platinum price 13% to $1,112/oz, raise our long-term palladium price 11% to $1,011/oz and raise our long-term rhodium price 36% to $3,000/oz.**

Exhibit 29: Gold cost curve evolution



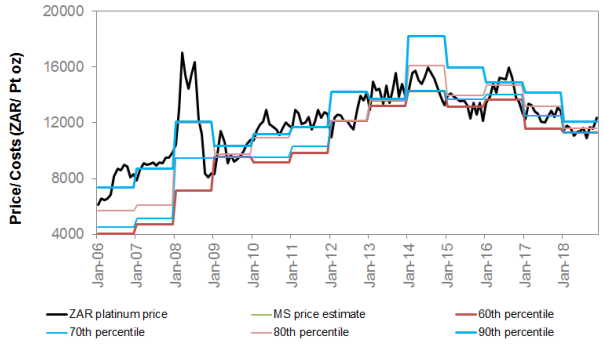
Source: Wood Mackenzie, company data, Morgan Stanley Research

Exhibit 30: Gold cost curve 2025 and long-term marginal cost



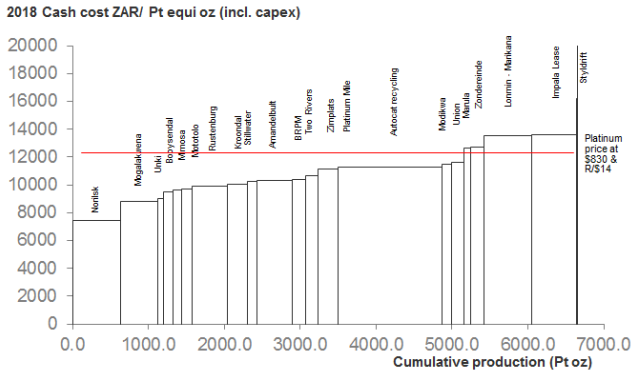
Source: Wood Mackenzie

Exhibit 31: Cost curve evolution in ZAR per platinum equivalent ounces



Source: Datastream, Company data, Morgan Stanley Research

Exhibit 32: PGM cost curve in ZAR per platinum equivalent ounces - 2018e



Source: Company data, Morgan Stanley Research

Exhibit 33: Gold project list and incentive price model outcome

Project	Owner	Country	Startup	Type	Mining Method	Capacity	Cash Costs (C1)	Estimated Project Capex		Sustaining Capex		IRR	LT Incentive Price
			Year			Au eq tonnes	US$/oz	US$m	US$/oz	US$m	US$/oz	US$/oz	US$/oz
TOTAL						**241**	**636.9**	**23,320**	**3,013**	**556**	**72**	**301.3**	**1,139**
Back River	Sabina Gold and Silver Corp.	Canada	2020	Greenfield	OP + UG	6	534.0	332	1,676	32	160	167.6	**933**
Blackwater	New Gold	Canada	2022	Greenfield	Open pit	13	578.0	1,865	4,499	40	98	449.9	**1,318**
Block 14	Orca Gold	Sudan	2021	Greenfield	Open pit	4	701.0	211	1,560	7	52	156.0	**975**
Caspiche Open Pit	Exeter Resource	Chile	2020	Greenfield	Open pit	8	551.0	371	1,396	51	194	139.6	**944**
Cerro Del Gallo	Argonaut Gold	Mexico	2020	Greenfield	Open pit	3	700.0	179	1,854	4	42	185.4	**1,006**
Coffee	Goldcorp	Canada	2021	Greenfield	Open pit	6	515.0	324	1,604	15	76	160.4	**820**
Converse	Waterton Global Resource Manag	USA	2024	Greenfield	Open pit	8	778.0	455	1,704	7	25	170.4	**1,046**
Curraghinalt	Dalradian	United Kingdom	2020	Greenfield	Underground	4	556.0	192	1,488	16	122	148.8	**891**
Donlin Creek	NovaGold / Barrick Gold	USA	2025	Greenfield	Open pit	40	630.0	6,679	5,138	56	50	513.8	**1,414**
Enchi	Pinecrest Resources	Ghana	2022	Greenfield	Open pit	2	802.0	84	1,364	4	72	136.4	**1,069**
Golden Highway	Moneta Porcupine	Canada	2021	Greenfield	Open pit	10	680.0	607	1,977	38	124	197.7	**1,086**
Halilaga	Liberty Gold	Turkey	2022	Greenfield	Open pit	8	670.4	346	1,359	16	61	135.9	**926**
Hasbrouck	West Kirkland Mining	USA	2019	Greenfield	Open pit	2	661.0	130	1,757	1	20	175.7	**932**
Heva-Hosco (Joanna)	Hecla Mining Company	Canada	2022	Greenfield	Open pit	3	746.0	422	3,902	7	67	390.2	**1,370**
Horne 5	Falco Resources	Canada	2021	Greenfield	Underground	7	260.0	802	3,645	28	127	364.5	**907**
Kemess UG	Centerra Gold Inc.	Canada	2022	Brownfield	Underground	3	639.0	452	4,264	16	154	426.4	**1,402**
Kiaka	B2Gold	Burkina Faso	2020	Greenfield	Open pit	11	671.0	610	1,794	22	66	179.4	**993**
Kingking	St. Augustine Copper-Gold	Philippines	2021	Greenfield	Open pit	14	610.0	2,310	5,193	21	47	519.3	**1,399**
Livengood	International Tower Hill Mines	USA	2023	Greenfield	Open pit	9	877.0	1,840	6,256	29	98	625.6	**1,869**
Loma Larga	INV Metals	Ecuador	2021	Greenfield	Underground	5	510.0	286	1,907	8	52	190.7	**835**
Magino	Argonaut Gold	Canada	2021	Greenfield	Open pit	4	663.0	321	2,773	4	39	277.3	**1,098**
Montagne d`or	Nordgold	French Guiana	2020	Greenfield	Open pit	7	666.0	361	1,687	19	90	168.7	**997**
Pinson Gold	Atna Resources	USA	2021	Greenfield	Open pit	1	626.0	67	2,186	0	0	218.6	**938**
Sleeper	Paramount Gold	USA	2021	Greenfield	Open pit	3	529.0	146	1,428	8	74	142.8	**807**
Stibnite	Midas Gold Corp	USA	2021	Brownfield	Open pit	10	653.0	970	2,879	7	21	287.9	**1,085**
Tocantinzinho	Eldorado Gold	Brazil	2021	Greenfield	Open pit	5	535.0	464	2,729	6	32	272.9	**957**
Toroparu	Sandspring Resources	Guyana	2021	Greenfield	Open pit	8	700.0	501	1,911	20	76	191.1	**1,049**
Yaoure	Perseus Mining Ltd.	Ivory Coast	2020	Greenfield	Open pit	5	734.0	263	1,728	6	38	172.8	**1,019**
Yellow Knife	GoldMining Inc	Canada	2023	Greenfield	OP + UG	3	853.9	193	2,398	5	60	239.8	**1,256**
Yimuyn Manjerr (Mt Todd)	Vista Gold	Australia	2020	Brownfield	Open pit	12	645.3	839	2,145	27	69	214.5	**1,021**
Springpole	First Mining Finance Corp.	Canada	2025	Greenfield	Open pit	13	619.1	586	1,391	10	23	139.1	**841**
Goldstrike	Liberty Gold	USA	2024	Greenfield	Open pit	3	793.0	113	1,192	26	273	119.2	**1,237**

Source: Company data, Wood Mackenzie, Morgan Stanley Research

Exhibit 34: PGMs project list and incentive price model outcome – note that study is in platinum equivalent ounces

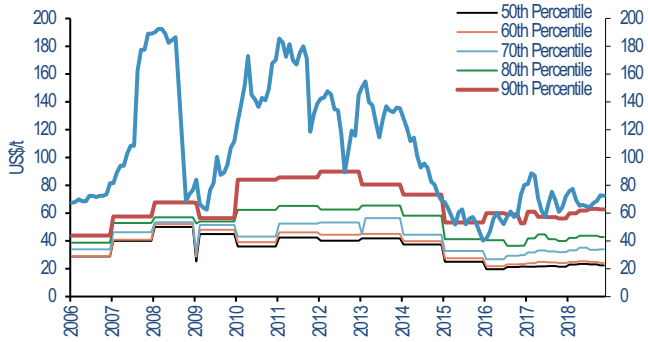
Project	Owner	Country	Full production	Startup	Type	Capacity	Cash Costs (C1 Composite)	Estimated Project Capex		Sustaining Capex		IRR	LT Incentive Price
			Year	Year		Pt equiv oz (000)	$/Pt equiv oz	US$m	$/Pt equiv oz	US$m	$/Pt equiv oz	$/Pt equiv oz	$/Pt equiv oz
TOTAL						**3,033**	**801.1**	**3,787**	**1,249**	**402**	**132.6**	**124.9**	**1,112**
Booysendal South	Northam	SA	2022		Brownfield	299	688.7	355	1,190	26.3	88.2	119.0	**947**
Styldrift	RBP	SA	2021		Greenfield	377	831.8	883	2,344	34.0	90.2	234.4	**1,257**
Blitz	Sibanye	US	2022		Brownfield	289	571.7	425	1,473	39.6	137.3	147.3	**919**
Mogalakwena expansion	Amplats	SA		2023	Brownfield	724	795.3	724	1,000	77.4	106.9	100.0	**1,045**
South cluster	Norilsk	Russia		2022	Brownfield	1,345	869.9	1,400	1,041	224.9	167.3	104.1	**1,186**

Source: Company data, Morgan Stanley Research

Iron Ore

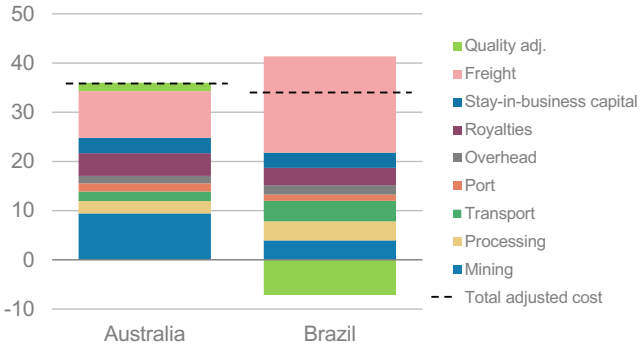
- Three large-scale and low-cost replacement iron ore projects are approved by BHP, Rio Tinto and Fortescue, with a cumulative capacity of 153Mtpa. The incentive prices of these projects are well below marginal cost – within a range of $35-39/t.
- However, incentive prices for unapproved projects are significantly higher at a weighted average $63/t. The non-approved pipeline has a cumulative capacity of 127Mtpa and average capital intensity of $79/t, with most producing a high-grade processed iron ore product.
- However, given we consider seaborne iron ore demand to be ex-growth, none of these projects may actually be required by 2025, as depletion is offset by the lower-cost, approved projects. As a result, we don't expect the iron ore price to reflect incentive price conditions over our forecast period.
- Instead, we set our long-term iron price using the 90th percentile of the 2025 seaborne + China cost curve, adjusted for quality and location differences. We estimate marginal cost (including stay-in-business capital) at $55/t for 62% Fe fines.
- **We increase our long-term iron ore price by 10% to $55/t, on a cfr China basis.**

Exhibit 35: Iron ore cost curve evolution



Source: Wood Mackenzie, company data, Morgan Stanley Research

Exhibit 36: Breakdown of 2018 iron ore costs Australia vs Brazil (US$/dmt, 62% Fe cfr China basis)



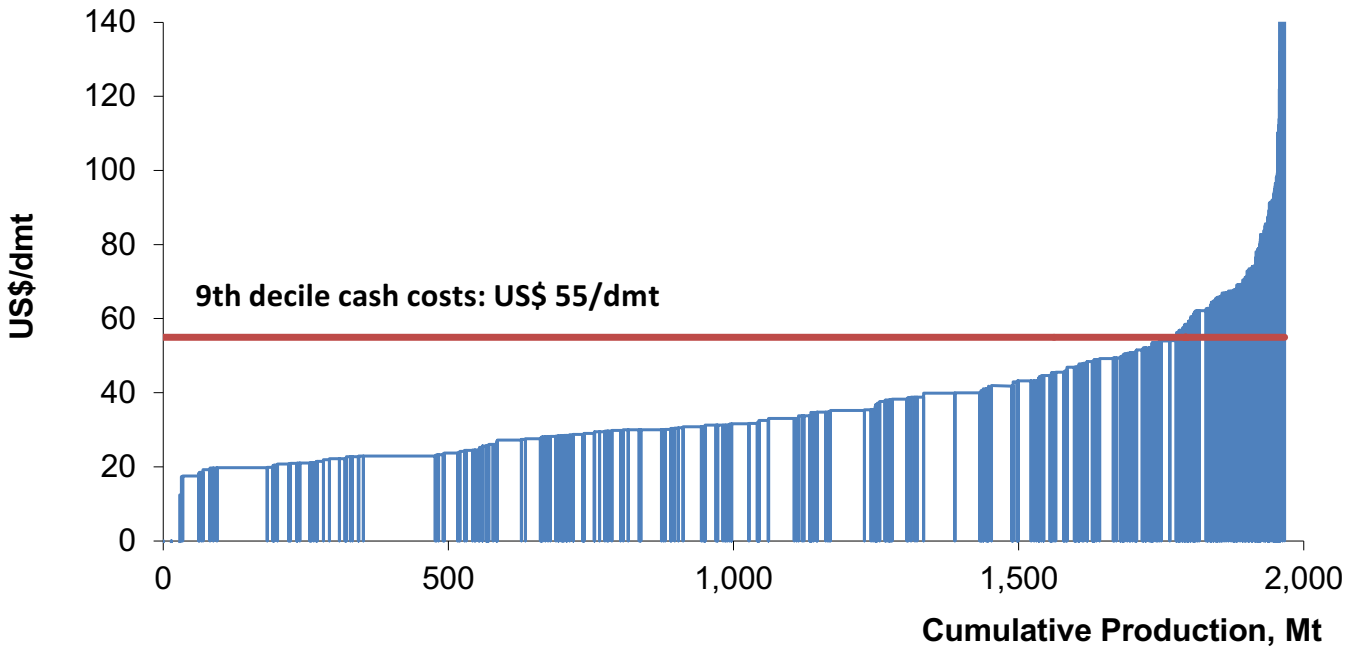
Source: Wood Mackenzie, Morgan Stanley Research

Exhibit 37: Iron ore project list and incentive price model outcome

Project	Owner	Country	Product	Startup	Type	Ore	Capacity	Cash Costs (total), fob	Discount to benchmark	Quality/location adjusted cash cost	Estimated Project Capex		Sustaining Capex		IRR	LT Incentive Price
				Year			Mt	US$/wmt	US$/dmt	US$/dmt	US$m	US$/t	US$m	US$/t	US$/t	US$/t
TOTAL							**280**	**26.7**	**-4.9**	**33.2**	**22,179**	**79**	**997**	**3.6**	**8.0**	**48**
Central Eyre Iron Ore Project	Iron Road	Australia	Concentrates	2024	Greenfield	Magnetite	22	35.0	-0.7	38.5	3,700	172	60.0	2.8	17.4	**66**
Corunna Downs	Atlas	Australia	DSO	2022	Greenfield	Hematite	4	35.0	-19.5	56.3	73	18	6.5	1.6	1.8	**61**
Hawsons	Carpentaria Exploration	Australia	Concentrates	2022	Greenfield	Magnetite	11	34.8	12.7	25.2	1,500	136	37.0	3.5	13.8	**48**
Iron Bridge - Stage 2	FMG/Iron Bridge	Australia	Concentrates	2024	Brownfield	Magnetite	10	53.0	6.5	50.8	1,050	111	20.0	2.1	11.2	**69**
Kami	Alderon Resources	Canada	Concentrates	2022	Greenfield	Magnetite	8	38.5	-4.6	44.9	1,000	125	11.0	1.4	12.6	**64**
Ludvika Mines (Blötberget)	Nordic Iron	Sweden	Concentrates	2020	Brownfield	Magnetite	1	44.0	6.5	40.2	181	127	4.7	3.3	12.8	**62**
Marillana	Brockman Mining	Australia	DSO	2021	Greenfield	Hematite	20	36.2	-16.5	53.1	1,500	75	63.0	3.2	7.6	**67**
Mary River - Stage 2	Baffinland	Canada	DSO	2020	Brownfield	Hematite	8	38.0	3.3	35.9	1,500	188	16.0	2.0	18.9	**65**
Pedra de Ferro - Stage 2	ERG	Brazil	Concentrates	2022	Greenfield	Hematite	19	32.0	-0.2	34.8	1,900	100	60.0	3.2	10.1	**52**
Pampa de Pongo	Jinzhao Mining	Peru	Concentrates	2022	Greenfield	Magnetite	25	45.2	-1.2	49.3	2,500	100	175.0	7.0	10.1	**71**
South Flank	BHP	Australia	DSO	2021	Greenfield	Hematite	80	18.5	-6.3	25.6	3,400	43	255.0	3.2	4.3	**35**
Eliwana	FMG	Australia	DSO	2021	Greenfield	Hematite	30	14.3	-14.2	29.7	1,275	43	83.0	2.8	4.3	**39**
Koodaideri	Rio Tinto	Australia	DSO	2021	Greenfield	Hematite	43	15.4	-4.6	21.1	2,600	60	206.0	4.8	6.1	**35**

Source: Company data, Wood Mackenzie, Morgan Stanley Research

Exhibit 38: Quality adjusted iron ore cost curve seaborne export + China domestic supply on 62% Fe fine, cfr China basis

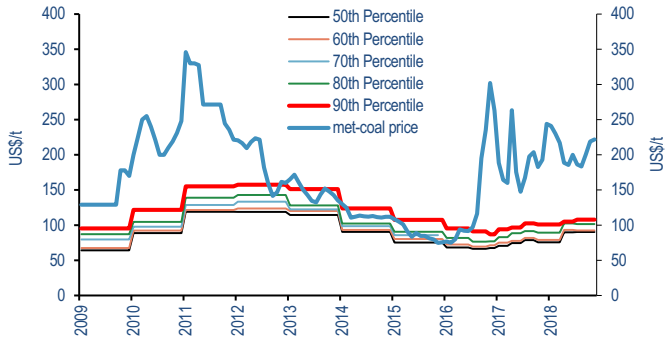


Source: Wood Mackenzie, Morgan Stanley Research

Metallurgical Coal

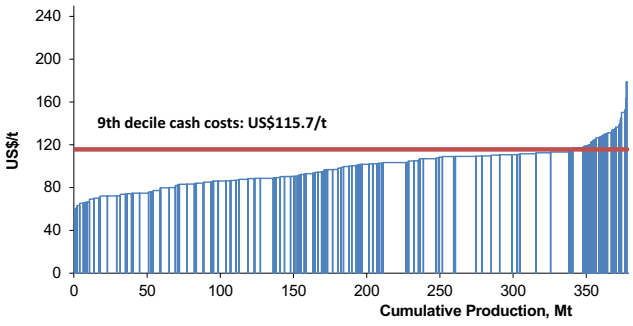
- Seaborne metallurgical coal demand continues to grow, mainly driven by rising demand from India, as it lacks a high-quality met coal endowment. Projects are required to satisfy this growing demand and to offset attrition of existing operations. One new project started in 2018, as Qcoal commissioned its 5Mtpa (50% HCC) Byerwen mine.
- Our pipeline of clearly defined projects is fairly limited – with 58Mtpa of capacity, of which 38Mtpa is classified as hard coking coal (HCC). The average capital intensity of these met coal projects is $90/t. Queensland, Australia, remains the key region for met coal supply in the long run, although we also see activity in Canada.
- Securing financing and obtaining mining licences are of particular difficulty for coal projects. We think that it's therefore justified to apply a 15% IRR to coal projects, rather than the 10% used for the other commodities, as developers are likely to have to show a higher IRR for coal projects.
- **We lower our long-term HCC price by 2%, to $124/t fob Aus.**

Exhibit 39: Met coal cost curve evolution



Source: Wood Mackenzie, company data, Morgan Stanley Research

Exhibit 40: Met coal cost curve 2025 and long-term marginal cost



Source: Wood Mackenzie

Exhibit 41: Metallurgical coal project list and incentive price model outcome

Project	Owner	Country	Startup	Type	Operation	Coal type	Capacity	Cash Costs (total), fob	Discount to benchmark	Quality/location adjusted cash cost	Estimated Project Capex		Sustaining Capex		IRR	LT Incentive Price
			Year				Mt	US$/t			US$m	US$/t	US$m	US$/t	US$/t	US$/t
TOTAL							**58**	**77.3**	**-22.2**	**99.7**	**5,249**	**90**	**297**	**5.1**	**13.5**	**124**
Aquila	Anglo American	Australia	2022	brownfield	Underground	HCC	3.5	82	-1	83	160	46	41.0	11.7	6.9	**104**
Blue Creek	Warrior Met Coal	United States	2022	greenfield	Underground	HCC	3.0	90	-18	108	500	167	13.5	4.5	25.0	**148**
Byerwen Ph II	QCoal	Australia	2025	brownfield	Surface	HCC/SCC/TC	6.5	80	-14	94	510	78	17.0	2.6	11.8	**113**
Eagle Downs	Baosteel/South32	Australia	2025	greenfield	Underground	HCC	4	81	-7	88	830	202	58.0	14.1	30.4	**145**
Freeport	Contura Energy	United States	2025	greenfield	Underground	HCC	2	71	-29	100	120	60	14.0	7.0	9.0	**120**
Grassy Mountain	Riversdale	Canada	2021	greenfield	Surface	HCC	4.5	80	-4	84	620	138	26.0	5.8	20.7	**119**
Makhado Lite	MC Mining	South Africa	2023	greenfield	Surface	HCC	1.8	60	-62	122	85	47	6.0	3.3	7.1	**135**
Murray River	HD Mining	Canada	2022	greenfield	Underground	HCC	4.8	85	-1	86	500	104	40.0	8.3	15.6	**117**
Olive Downs Ph 1	Pembroke Resources	Australia	2021	greenfield	Surface	HCC/SCC/PCI	4.2	74	-27	101	345	82	12.7	3.0	12.3	**121**
Ovoot	Aspire Mining	Mongolia	2025	greenfield	Surface	HCC	5.0	85	-50	135	144	29	13.0	2.6	4.3	**144**
Quintette	Teck	Canada	2023	brownfield	Surface	HCC	4.0	77	-1	78	500	125	20.0	5.0	18.8	**110**
Vickery	Whitehaven	Australia	2022	greenfield	Surface	SCC	8.5	70	-41	111	512	60	17.0	2.0	9.0	**126**
Winchester South	Whitehaven	Australia	2024	greenfield	Surface	HCC/SCC/PCI/TC	6.5	69	-34	103	423	65	19.0	2.9	9.8	**120**

Source: Company data,Wood Mackenzie, Morgan Stanley Research

Thermal Coal

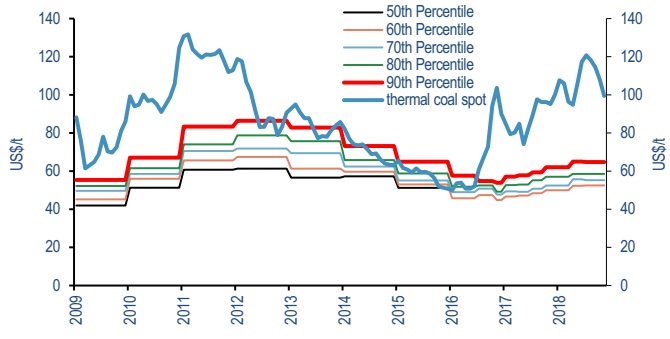
- In the long term, environmental pressures and advances in renewable technologies are driving a shift away from thermal coal power generation. Meanwhile, coal projects will be required – not only due to depletions at existing operations, but also to offset the decline in underlying quality (energy content) of the seaborne market. One new coal mine opened in 2018 – March Energy's Mount Pleasant mine in Australia's Hunter Valley, with 8Mtpa capacity.

- The lack of investment in new supply is a key issue in thermal coal – in previous cycles, the price peak was the point for investments in thermal coal projects. This time, not only are a lack of financing and difficulty obtaining mining licences a hurdle, but also the fear of demand falling away quicker than anticipated is making miners hesitant. As for met coal, we therefore apply a 15% IRR in our thermal coal incentive price analysis.

- The pipeline of thermal coal export projects has a capacity of 100Mtpa, with an average capital intensity of $57/t. The most debated project in our analysis is Adani's self-financed Carmichael project in Queensland, Australia. This project is a showcase for the difficulty in new coal projects – it's been scaled down from 60Mtpa to 26Mtpa, and from a dedicated railway to a connection to the existing rail system, in order to reduce capex and negate the need for external funding.

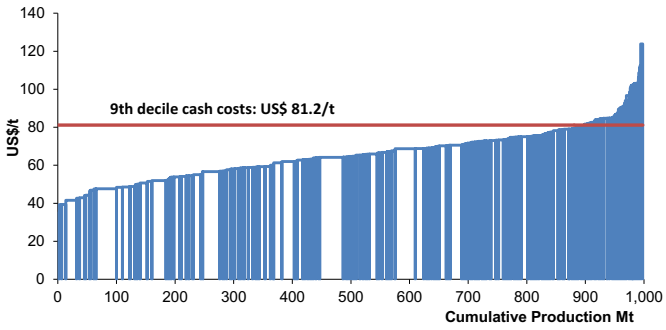
- **We increase our long-term thermal coal price by 8% to $75/t on a 6,300kcal/kg GAR fob Australia basis.**

Exhibit 42: Thermal coal cost curve evolution



Source: Wood Mackenzie, company data, Morgan Stanley Research

Exhibit 43: Thermal coal cost curve 2025 and long-term marginal cost



Source: Wood Mackenzie

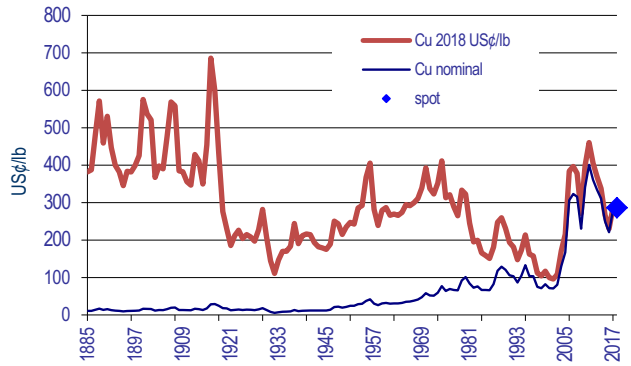
Exhibit 44: Thermal coal project list and incentive price model outcome

Project	Owner	Country	Startup	Type	Operation	Capacity	Cash Costs (total), fob	Discount to benchmark	Quality/location adjusted cash cost	Estimated Project Capex		Sustaining Capex		IRR	LT Incentive Price
			Year			Mtpa	US$/t			US$m	US$/t	US$m	US$/t	US$/t	US$/t
TOTAL						**101**	**48.7**	**-9.9**	**59.0**	**5,735**	**57**	**340**	**3.3**	**8.5**	**75**
Angus Place Extension	Banpu	Australia	2022	brownfield	Underground	4	40.6	-18.5	59	175	46	9	2.4	6.9	**71**
Asmin Bara Jaan	United Tractors	Indonesia	2023	greenfield	Surface	3	64.0	-14.7	79	40	14	5	1.7	2.1	**83**
Blakefield North	Glencore	Australia	2023	brownfield	Underground	5	46.5	3.0	44	325	65	46	9.2	9.8	**67**
Boikarabelo	Resgen	South Africa	2021	greenfield	Surface	6	40.0	-25.7	66	370	62	18	3.0	9.3	**82**
Carmichael	Adani	Australia	2023	greenfield	Surface	26	50.0	-17.5	68	1,500	58	80	3.1	8.7	**83**
Dartbrook	Australian Pacific Coal	Australia	2025	brownfield	Surface	8	41.0	-6.5	48	740	97	20	2.6	14.6	**71**
Elders	Anglo American	South Africa	2024	greenfield	Surface	4	48.0	-14.0	62	200	57	11	3.1	8.6	**77**
Maxwell	Malabar Coal	Australia	2025	greenfield	Underground	5	50.0	11.5	39	400	80	15	3.0	12.0	**59**
New Acland Stage 3 Extension	New Hope	Australia	2021	brownfield	Surface	7	54.0	-2.0	56	360	51	17	2.4	7.7	**69**
Similca Rincon Hondo	Drummond	Colombia	2022	greenfield	Surface	10	47.5	-3.0	51	170	17	30	3.0	2.6	**57**
Springboklaagte	Glencore	South Africa	2024	greenfield	Underground	2	42.0	-22.0	64	65	41	6	3.4	6.1	**76**
Thabametsi	Exxaro Resources	South Africa	2021	greenfield	Surface	5	22.2	-32.5	55	220	46	18	3.6	6.9	**68**
Valeria	Glencore	Australia	2025	greenfield	Surface	10	54.0	-4.0	58	470	47	30	3.0	7.1	**71**
Vista Coal Project	Cline Group	Canada	2020	greenfield	Surface	5	65.5	-6.7	72	550	106	20	3.8	15.9	**99**
Wambo South	Peabody	Australia	2023	brownfield	Underground	3	64.0	4.0	60	150	50	16	5.3	7.5	**76**

Source: Company data,Wood Mackenzie, Morgan Stanley Research

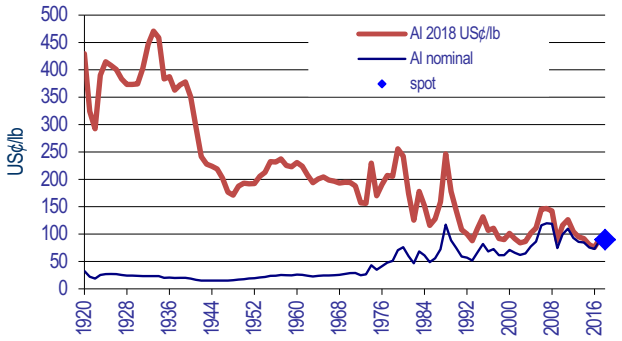
Historical Annual Prices

Exhibit 45: Copper prices



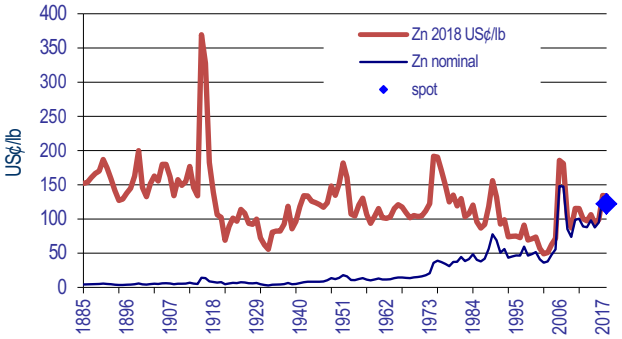
Source: USGS, Bloomberg, Morgan Stanley Research

Exhibit 46: Aluminium prices



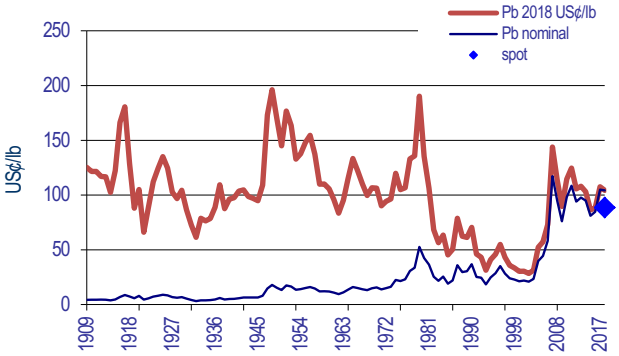
Source: USGS, Bloomberg, Morgan Stanley Research

Exhibit 47: Zinc prices



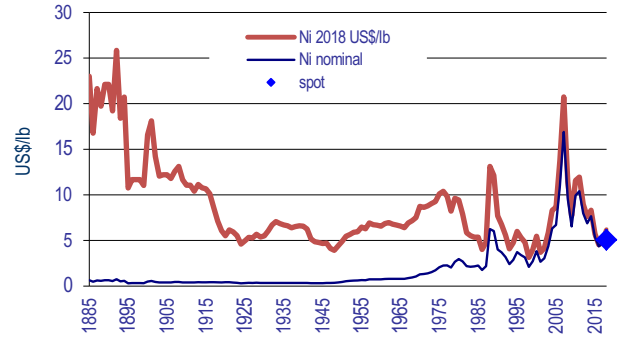
Source: USGS, Bloomberg, Morgan Stanley Research

Exhibit 48: Lead prices



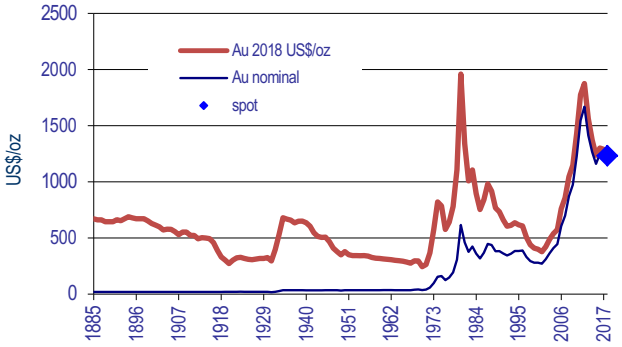
Source: USGS, Bloomberg, Morgan Stanley Research

Exhibit 49: Nickel prices



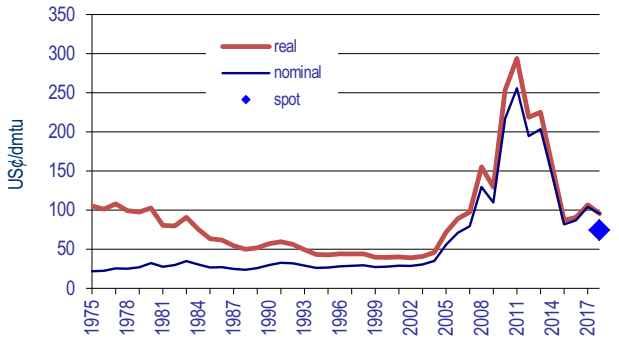
Source: USGS, Bloomberg, Morgan Stanley Research

Exhibit 50: Gold prices



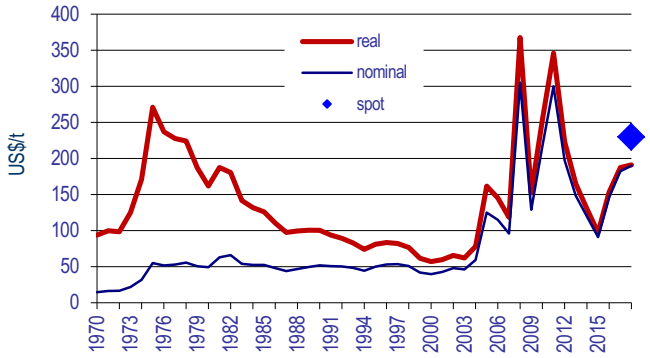
Source: USGS, Bloomberg, Morgan Stanley Research

Exhibit 51: Iron ore fines prices



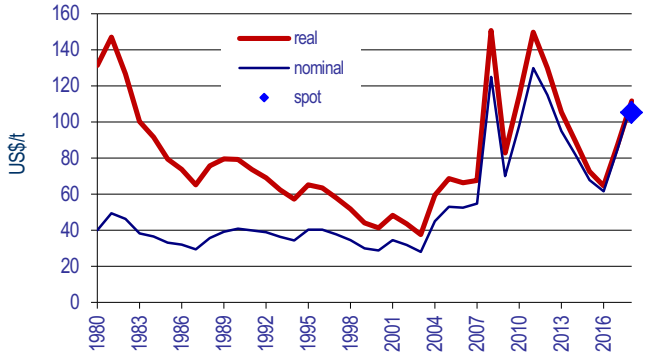
Source: Tex Report, UNCTAD, Bloomberg, Morgan Stanley Research

Exhibit 52: HCC contract price



Source: Tex Report, UNCTAD, Bloomberg, Morgan Stanley Research

Exhibit 53: Thermal coal contract price



Source: Tex Report, UNCTAD, Bloomberg, Morgan Stanley Research

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	COVERAGE UNIVERSE		INVESTMENT BANKING CLIENTS (IBC)			OTHER MATERIAL INVESTMENT SERVICES CLIENTS (MISC)	
STOCK RATING CATEGORY	COUNT	% OF TOTAL	COUNT	% OF TOTAL IBC	% OF RATING CATEGORY	COUNT	% OF TOTAL OTHER MISC
Overweight/Buy	**1156**	**37%**	**295**	**40%**	**26%**	**541**	**38%**
Equal-weight/Hold	**1405**	**44%**	**342**	**47%**	**24%**	**641**	**45%**
Not-Rated/Hold	**46**	**1%**	**7**	**1%**	**15%**	**7**	**0%**
Underweight/Sell	**555**	**18%**	**85**	**12%**	**15%**	**226**	**16%**
TOTAL	**3,162**		**729**			**1415**	

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