Global Metals & Mining

Manganese ore Primer 4.0

Bank of America Merrill Lynch

Primer

Equity | 20 November 2019

Lower Mn prices: flatter cost curves, more production

We publish the 4th edition of our manganese ore primer and consider key factors impacting pricing: 1) A flattening cost curve (oil, ZAR); 2) Higher "value in use" discounts for lower grade producers exposed to the ferroalloys market; 3) Supply, especially Eramet's plans to add substantial volume (+2.5 Mtpa / 5%) to the seaborne market with an expansion of its Moanda mine in Gabon; 4) Relatively elevated port inventories in China. On demand, we expect China steel demand growth to slow but stay positive. Companies with manganese exposure include: Eramet (49% of revenue), African Rainbow Minerals (Mn 24% of revenue), South32 (21% of revenue), Vale & Anglo American.

China remains dependent on Mn ore imports

In terms of Chinese domestic manganese ore supply, we see depleting domestic ore resources and falling manganese grades supporting demand for seaborne ores, even in a scenario of subdued steel demand growth. **Depleting resources:** China resources estimated at just 40Mt of contained manganese vs. South Africa at >170Mt contained. **Lower manganese grades:** It is estimated that 96% of Chinese mine reserves are low grade at just 21% Mn vs. the 44% Mn benchmark. Based on these factors, we observe import dependency rising from 54% of 2012 Chinese consumption to 74% in 2018.

Chinese steel demand growth: Slowing.

China produces and consumes more than 50% of global carbon steel with demand driven largely by property, infrastructure & manufacturing. We expect China steel demand growth to slow to +2.3% in 2020 from a torrid c. +7% pace in 2019. Steel demand from property and infrastructure (c.50% of total Chinese steel demand) should grow by 9.5% / 7% and 1.7% / 7.1% in 2019E and 2020E.

Supply: Volume growth from Gabon. South Africa capped.

Eramet announced its decision to expand Moanda (Gabon) in 2019. It will deliver 7Mt annually of Mn ore by end-2023 (currently production 4.5Mt for 2019). This should contribute +5% to world manganese supply (assuming 44% Mn). If executed according to plan, the extension will likely soften Mn prices as Eramet is one of the lowest cost producers. This should flatten the cost curve by pushing out higher cost producers. South Africa has abundant reserves and the cost positions of the mines are generally compelling, suggesting supply could / should increase. However, we do see supply growth capped by infrastructure availability (particularly rail, and to a lesser extent, ports). With Manganese a relatively low value, bulk commodity, transport & logistics are key. That said, South Africa does remain the largest supplier of manganese ore to the seaborne market. In 2018, 47% of global seaborne ore exports came from South Africa.

Global
Non-Ferrous Metals, Mining & Minerals

Jason Fairclough >>
Research Analyst
MLI (UK)
+44 20 7995 0225
jason.fairclough@bofa.com

James Redfern >>
Research Analyst
Merrill Lynch (Australia)
james.redfern@bofa.com

Kevin Kerdoudi >>
Research Analyst
MLI (UK)
+44 20 7996 7589
kevin.kerdoudi@bofa.com

Olivia Du >>
Research Analyst
MLI (UK)
olivia.du@bofa.com

Anton Fedotov >>
Research Analyst
Merrill Lynch (Russia)
anton.a.fedotov@bofa.com

Patrick Mann, CFA >>
Research Analyst
Merrill Lynch (South Africa)
patrick.mann@bofa.com

Timna Tanners
Research Analyst
BofAS
timna.tanners@bofa.com

Matty Zhao >>
Research Analyst
Merrill Lynch (Hong Kong)
matty.zhao@bofa.com

Lawson Winder, CFA >>
Research Analyst
Merrill Lynch (Canada)
lawson.winder@bofa.com

Michael Widmer
Commodity Strategist
MLI (UK)
michael.widmer@bofa.com

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Refer to important disclosures on page 25 to 27.

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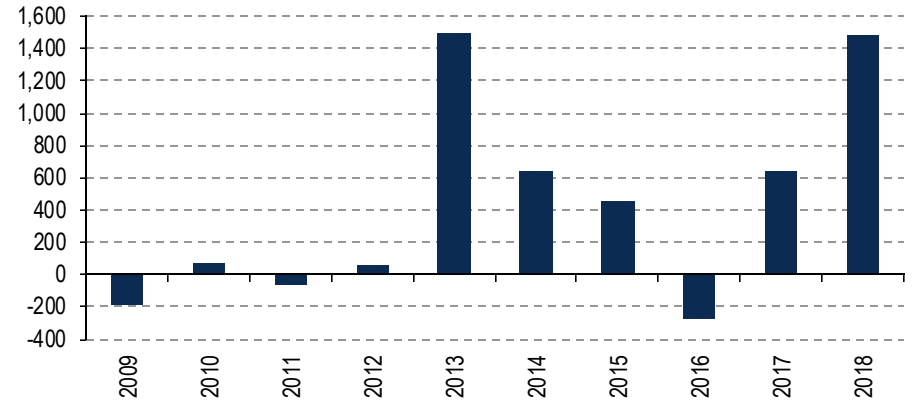
Manganese is not supply constrained

The manganese market was oversupplied by c.1490kt in 2018, with supply (+14% YoY) outpacing demand (+10% YoY). Higher production was driven by South African, Indonesian and Malaysian producers. China remained the largest consumer of Manganese ore, generating c.62% of global demand (contained Mn). Expectations are for a balanced manganese ore market in the medium-term.

Chart 1: Manganese ore supply demand model



Source: CRU

China has constrained capacity. Offset by expansion at Moanda?

On the Chinese domestic market, local mined supply is constrained due to falling grades and depleting resources. Additionally, the government has imposed production restrictions as part of supply side reforms. As a result, demand for higher grade seaborne imports should be well supported, in our view.

Outside of China we see producers prioritising a "value over volume" approach with infrastructure bottlenecks capping potential supply additions from largest seaborne supplier, South Africa. That said, Eramet is currently extending Moanda to increase ore production volume to 7Mt by 2023 vs 4.5Mt in 2019 (market size: c. 21Mt).

Table 1: Supply / Demand balance

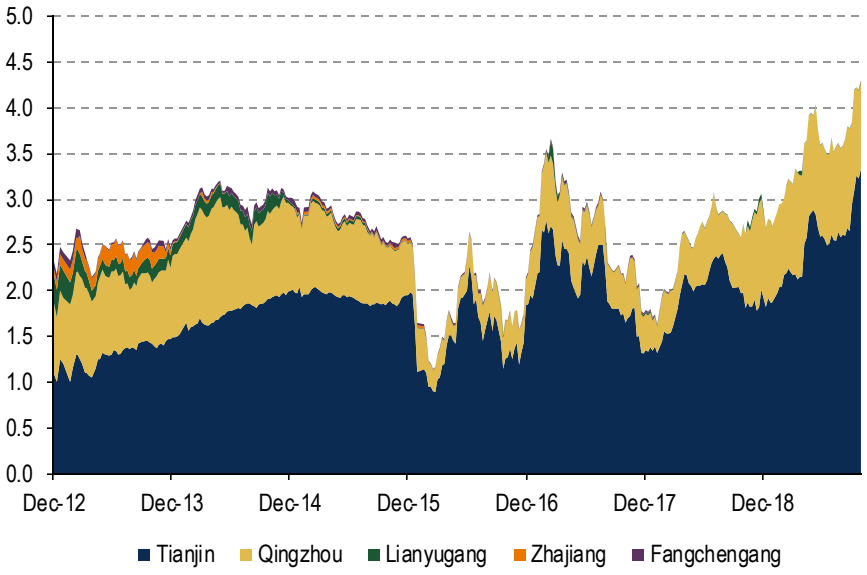
Supply/Demand Balance:	2009A	2010A	2011A	2012A	2013A	2014A	2015A	2016A	2017A	2018A
World Production	**12,256**	**15,671**	**16,540**	**16,715**	**18,759**	**19,256**	**16,325**	**17,039**	**19,820**	**22,633**
Y/Y Change, %	*-20%*	*28%*	*6%*	*1%*	*12%*	*3%*	*-15%*	*4%*	*16%*	*14%*
World Consumption	**12,448**	**15,602**	**16,601**	**16,659**	**17,264**	**18,617**	**15,865**	**17,319**	**19,184**	**21,143**
- in Mn Alloys	10,570	13,589	14,593	14,960	15,651	16,744	14,275	15,535	16,631	18,893
- in other uses	1,879	2,013	2,008	1,699	1,613	1,873	1,590	1,784	2,553	2,250
Y/Y Change, %	*-13%*	*25%*	*6%*	*0%*	*4%*	*8%*	*-15%*	*9%*	*11%*	*10%*
Market balance	**-193**	**69**	**-60**	**57**	**1,495**	**640**	**460**	**-280**	**636**	**1,490**

Source: CRU

Port stocks are high

Port stocks of Manganese in China are relatively elevated and we consider a potential weak end to 2019. That said, seasonally, we often see restocking of steelmaking raw materials coming into Chinese New Year and don't rule out an early 2020 price rally off the lows.

Chart 2: Chinese port stocks of Manganese ore (Mt)



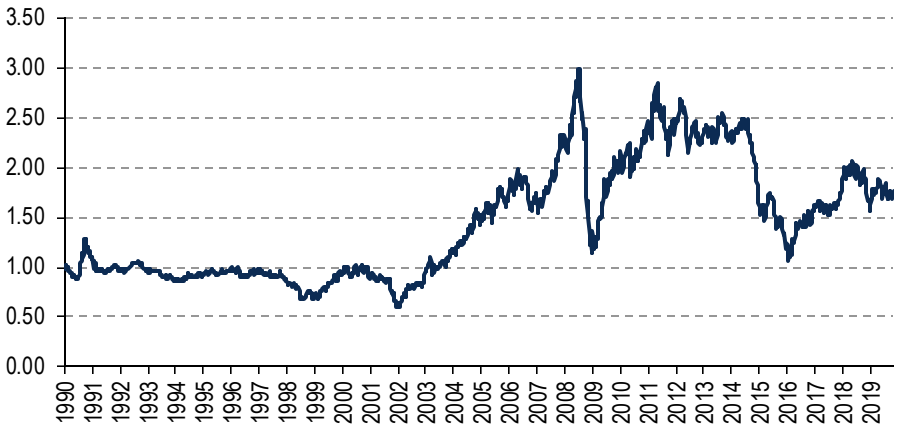
Source: Wind

Flattening cost curves = lower prices

Is cost deflation back? From 2016 to 2018, we saw strengthening commodity currencies, higher oil prices and higher freight costs driving overall cost inflation in mining. However, we hit an inflection point in early 2018. This drives unit costs lower across the commodities with limited exposure to tight labour markets (Australia) due to so called "flattening cost curves". Falling costs suggest prices could be "lower for longer".

To quantify this we derived a theoretical "spot cost indicator" where we assume a cost breakdown of 60% oil and 40% labour (using ZAR as a proxy) for bulk manganese producers in South Africa. On this spot costs have increased over 3.5x vs. 1990 levels by the peak of the cycle in 2008. Post an aggressive pullback in 2009 (both oil and emerging market currency impact) these were again driven higher by the commodity "bubble" reflated by Chinese stimulus before deflating again with a downward trend until early 2016. Between 2016 and 2018, our spot cost index nearly doubled.

Chart 3: ZAR bulks producer "spot" cost indicator, 1990 = 100



Source: BofA Merrill Lynch Global Research estimates

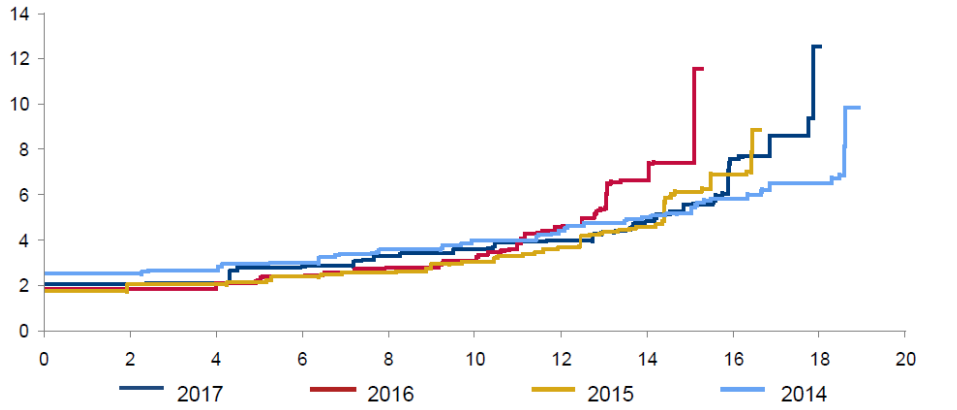
Disclaimer: The indicator identified above as the ZAR bulk producer "spot" cost indicator is intended to be an indicative metric only and may not be used for reference purposes or as a measure of performance for any financial instrument or contract, or otherwise relied upon by third parties for any other purpose, without the prior written consent of BofA Merrill Lynch Global Research. This indicator was not created to act as a benchmark.

The increase in costs we saw over the period 2016-2018 has now stopped. This was consistent with a trend of steepening cost curves observed across the commodity complex. Should we expect a new cyclical low for costs in the manganese space in the near term? We now see potential for flattening cost curves as a result of:

- Decreasing freight/logistics costs driven by lower oil prices since September 2018
- Commodity currencies weakening supporting producer margins
- Economies of scale through brownfield projects / mine extension. Lower commodity prices (due to lower demand) + higher supply = negative for prices.
- Lower oil price also driving broader cost deflation.
- Limited tightness in labour markets in key supply countries (South Africa, Gabon)

CRU data highlights the phenomenon of steepening cost curve in manganese between 2014 and 2017.

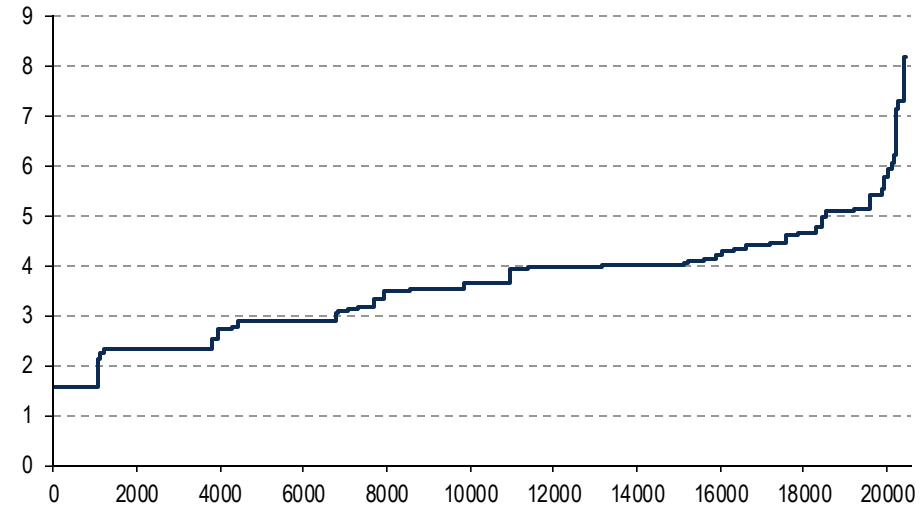
Exhibit 1: Trend in cost curve steepening 2014-2017



Source: CRU International

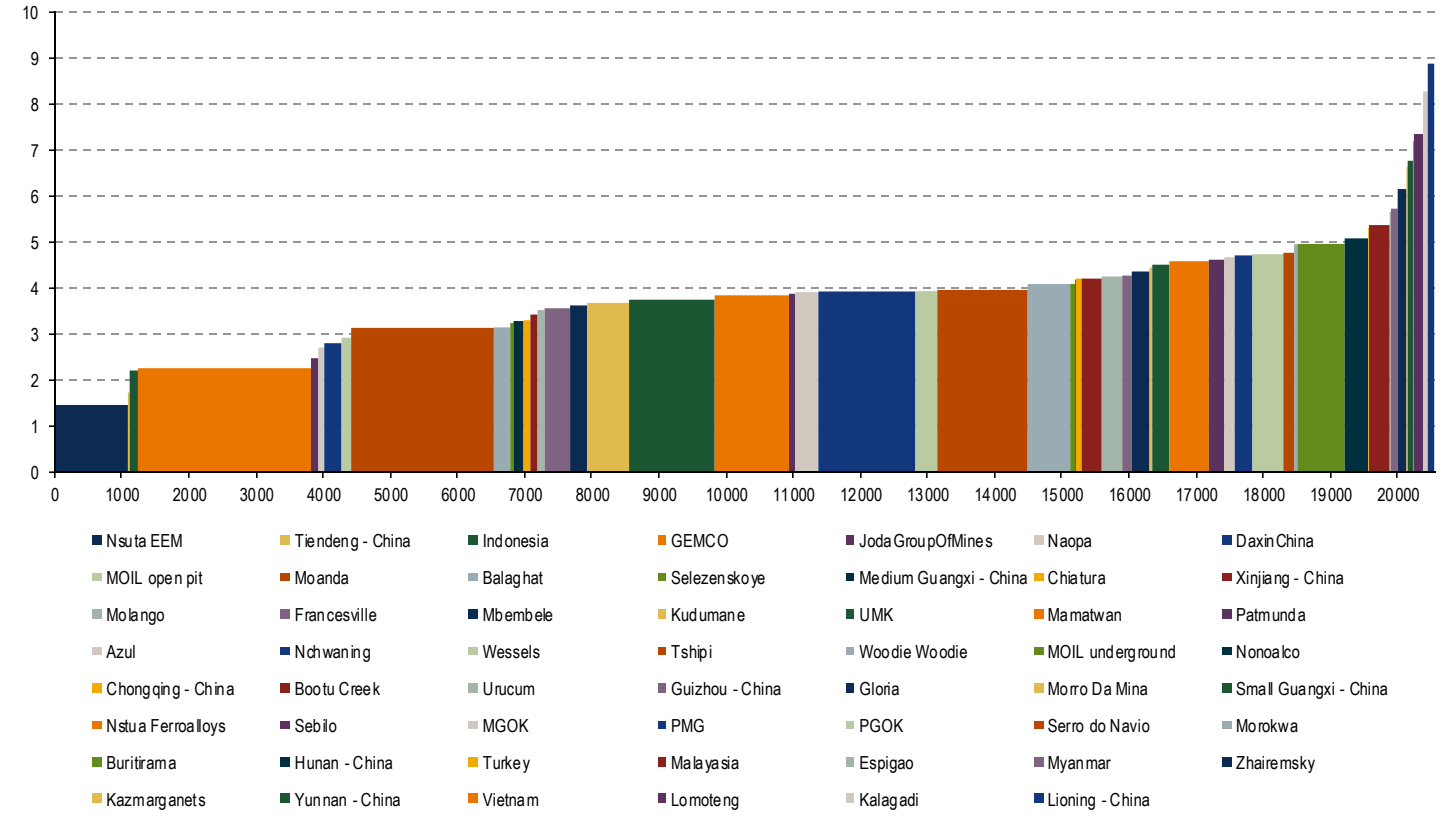
We observe a flattening of the cost curve in 2018. In particular, the high cost "shoulder" has dropped from > US$6/dmtu to about US$5/dmtu (our new long-term price).

Chart 4: 2018A cost curve ($/dmtu) – flatter than before



Source: BofA Merrill Lynch Global Research, CRU International

Chart 5: 2020E cost curve ($/dmtu)



Source: BofA Merrill Lynch Global Research estimates, CRU International

“Value in use” discounts seem structural

High grade ores demanding higher prices beyond contained manganese.

Value in use is a way of thinking about other costs and benefits in choosing a particular ore beyond just the value of the contained metal within the ore. This is particularly pertinent for manganese where using high grade ore in the production of steel lowers costs by using less reluctant, flux and electricity.

Table 2: Value is use comparison when producing manganese alloys depending on ore input quality

		High grade ore	Low grade ore
INPUTS	Ore required, metric ton	1.8	3.4
	Ore grade average, Mn	48%	32%
	Reductant, metric ton	0.41	0.48
	Flux, metric ton	0.01	0.8
	Electricity, MWh	2.2	3.3
OUTPUT	HCFeMn, metric ton	1	1
	HCFeMn grade	75%	70%
	Slag, metric ton	0.5	1.9
	Slag (%MnO)	34%	19%

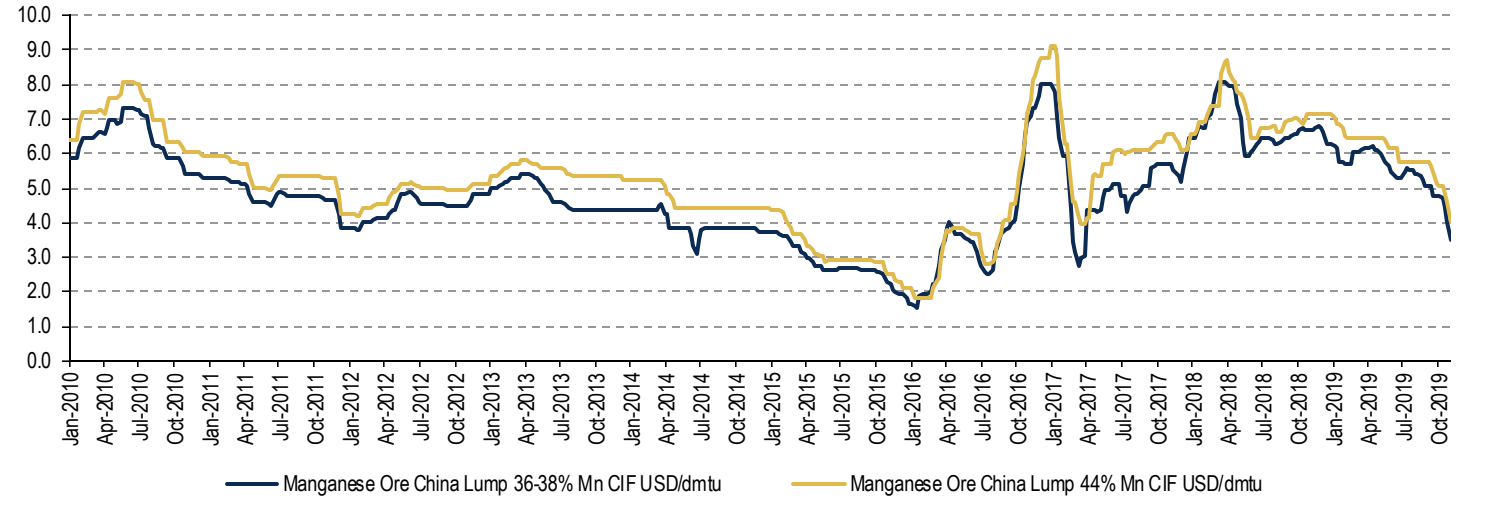
Source: BHP Billiton company reports

The Chinese steel industry is the key demand driver for manganese ore and Chinese demand trends continue to dictate price. High-quality manganese ores are seeing (structurally) greater demand amidst tighter environmental regulation globally and supply side reform. Over 2017 and 2018 we observed value in use discounts increasing for all lower quality (lower grade, higher impurities) steel making raw materials. We note the following drivers for this development:

- Chinese steel producers have looked to maximise output: Feeding higher grade raw materials into a blast furnace yields more crude steel for every ton of raw material processed.
- Government imposed restrictions on emissions from Chinese blast furnaces has pushed steel producers to demand higher grade product which, when processed, result in lower emissions/slag (see value in use equation above).

The following chart highlights how up until the beginning of 2017 we observe a relatively stable differential between high grade (44%) manganese ore prices and lower grade prices. In 2017 and 2018, the discount for lower grade products increased.

Chart 6: Mn ore prices: Higher grades trade at a premium to lower grade ore



Source: CRU International

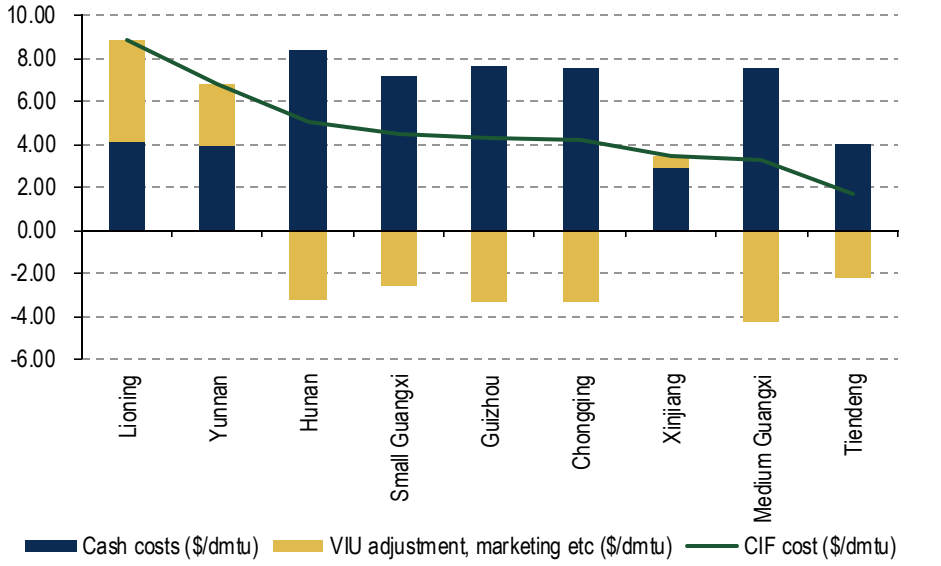
With China seemingly firmly committed to cutting emissions from its steel industry and prioritising its "blue sky initiatives", we think higher value in use discounts for lower quality products are structural.

Value in use discounts the largest "cost" for Chinese manganese mines

Value in use adjustments to prices of low ore grade is one of the largest costs for manganese mines in China.

Hunan mine is the one of the largest cost producer in the region where ore grade was 12% in 2018. The lowest Chinese cost producer is Xinjiang with an ore grade of c. 36%. Given that high grade, Xinjiang has the lowest VIU adjustment of all Chinese mines.

Chart 7: VIU adjustment is one of the largest "costs" for Chinese mines



Source: BofA Merrill Lynch Global Research estimates, CRU International

What does this means for the cost curve?

Higher discounts for lower quality ores effectively means higher prices necessary on a 44% manganese ore equivalent basis in order for lower quality producers survive. In other words, we could consider manganese ore prices relative to producer margin curve rather than a producer cost curve with higher prices necessary to support producers of lower quality product.

However, when nickel price is high and/or too volatile, we note that stainless steel producers look for raw material alternatives and can use manganese as a substitute. While manganese is about half as effective as is nickel, it remains cost efficient in the EMM (Electrolytic Manganese Metal) production used for the production of 200-series stainless steel.

As a result, in order to reflect the technical strengths for use in EMM of some of the lower grade Chinese mines, the VIU adjustment could allow them to sit lower on the cost curve.

This also suggests that Chinese demand for higher grade imported manganese ore should remain healthy and is supportive of a discount for lower quality products.

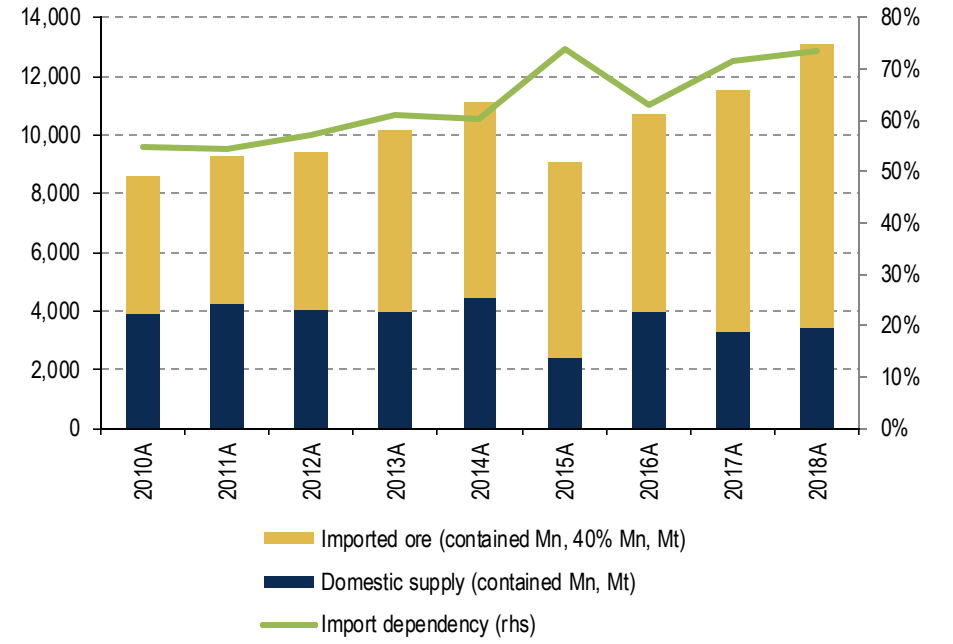
China depends on imported ore

We take a closer look at Chinese domestic manganese ore supply. We see depleting domestic ore resources and falling manganese grades supporting Chinese demand from high grade imported ore further supporting prices.

- **Depleting resources:** China resources estimated at just 40Mt of contained manganese vs. South Africa at >170Mt contained.
- **Lower manganese grades:** It is estimated that 96% of Chinese mine reserves are low grade at just 21% Mn vs. the 44% Mn benchmark

We believe that higher cost local Chinese Manganese ore producers are exiting the market either due to poor economics or due to simply having exhausted their ore reserves. Whereas much of the marginal tonnage used to be lower grade local mines, "value in use" in now recognized as an important driver of profitability. China has become increasingly dependent on imported ore to feed its ferroalloys industry; we see import dependency at c. 90% in 2019. There are still a few higher cost low-grade Chinese producers on our cost curve but our assumption is that many/most of these will cease production over the next few years.

Chart 8: China manganese ore consumption by source (kt)



Source: BofA Merrill Lynch Global Research estimates, CRU international

Supply side reform, environmental protection also support demand for higher grade imports and puts pressure on domestic mine supply.

China's government initiated its supply-side reform policies in 2016 to tackle the severe overcapacity issues in China, starting with the coal and steel industries. In early FY16, the Central government set up a long-term target to close down 140mnt blast furnace capacity during FY16-20E, and allocated RMB100bn funding for laid-off staff compensation. Policies have extended to other basic material industries including cement, glass, iron ore and manganese ore mining.

China's government has paid more attention on the environmental protection and determined to solve the pollution issue since. We observe more than normal environmental checks as the Central government sent around inspection teams down to

each province from time to time. Manganese mines are quite polluting and more restrictions from environmental protection perspective were also seen in FY16-17. Government took away shovels and/or withdrawn environment certificates forcing mines to close. We expect the trend to continue.

In addition, as an effort to improve air quality in Beijing City and nearby regions, the government require to suspend some steel blast furnace capacity in North China during winter heating season, particularly for the "2+26" cities of Beijing, Tianjin, Hebei, Shandong, Henan and Shanxi.

In November 2018, more stringent regulation was imposed on Chinese steel mills. Steel mills were required to cease production of 355-Mpa tensile strength rebar in favour of 600Mpa-tensile rebar. Manganese alloys are key in the steelmaking process to improve tenacity and we thus included increased forecasts of ore imports into China by +2.6 – 3.0 Mt till 2023 (32Mt).

Supply discipline continues but downside risk to price exists...

While China remains the largest producer of manganese ore it is a net importer due to low grades (quality) and shrinking reserves. South Africa, Australia and Gabon constitute >50% of global ore exports. We do not see manganese as resource constrained on a long term basis meaning supply discipline is important. We think supply discipline will continue albeit to a lesser extent than previously estimated due to new projects that will expand production.

In 2016 we saw supply cuts when ore prices hit a record lows, with miners, led by S32 choosing to pursue a "value over volume" approach. However, we note that Eramet is planning to extend its manganese mine in Gabon, Moanda. This will add c.5% to world 2018 production (contained Mn) by 2023. As Moanda is one of the lowest Mn cost producers (first tier of the cash cost curve), the ramp up is likely to soften manganese prices. When we discuss the market impact of the project with Eramet's management, they mention a loss of market share to South African producers, especially higher cost, trucked suppliers.

That said, supply restraints will continue to exist in key producer South Africa (c.27% of global supply). While there is some scope for brownfield expansions here, we see only a small volume of new supply coming online as a result of infrastructure bottlenecks capping growth.

Eramet ramping up manganese production

In March 2019, Eramet announced its decision to expand Moanda, which will deliver 7Mt annually of Mn ore by end-2023 (currently production is 4.5Mt for 2019). This will contribute +5% to world manganese supply (assuming 44% contained Mn). A new washing plant to handle mineral supplies from Bangombe and Okouma will also be constructed. Simultaneously, the Moanda mineral station and Owendo port will be upgraded. Capex are estimated to be c. EUR600mn, to be spread over 5 years from 2019. The company should announce financing method at end of 2019 / beginning of 2020.

If executed according to plan, the extension will likely soften Mn prices as Eramet is one of the lowest cost manganese producers. This would flatten the cost curve, pushing out higher cost producers. Moanda lies in the first tier of the cost curve, with unit cash costs at $2.06 /dmtu in 2018, putting it slightly behind S32's GEMCO, which has unit cash costs of $1.75 /dmtu.

South African logistics constraints cap supply additions near-term

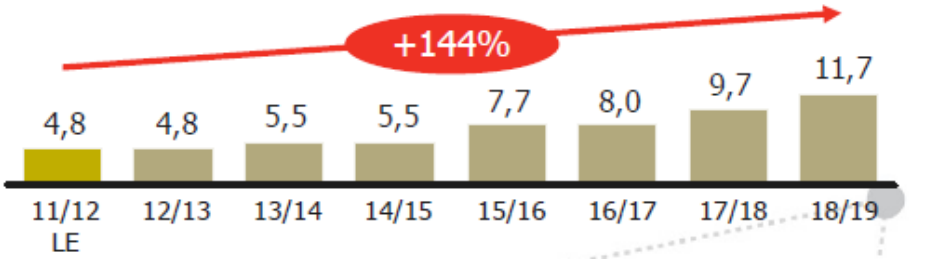
South Africa is the largest supplier of manganese ore to the seaborne market. In 2018 47% of global seaborne ore exports came from South Africa. Reserves and the cost position of mines are generally compelling suggesting potential economics to increase supply could be supportive. Nevertheless we see supply growth potential as capped by infrastructure (particularly transport) bottlenecks. While Transnet (SOE railway-company) expanded its railway capacity in 2018, it has under delivered on promised railway capacity expansions. Incremental volumes can be trucked, but with associated higher costs. Estimates show that c. 3.7Mt of ore from South Africa was trucked in 2018 (vs. 14Mt by rail).

Post 2020, SA supply could grow if Transnet performs. So far delivery has disappointed.

Post 2020, if Transnet delivers, there is potential for higher South African seaborne supply as rail capacity rises. We expect most of the potential added ore supply from South Africa to come from the mid-sized miners. South Africa's manganese exports are primarily directed through Port Elizabeth but the ports of Durban, Cape Town and Saldanha are all gaining importance. New deep water port Ngqura 20km north of Port Elizabeth could add capacity of c. 300ktpa. South Africa exported 17.7Mt of ore in 2018, of which we estimate c. 75% was railed.

South African rail provider Transnet is the sole rail provider and will be key to exports in our view. The company's 2012 Market Demand Strategy (MDS) calls for an increase in rail capacity to 16Mtpa of manganese by 2023 for total capex of c. ZAR27bn (at 2014 ZAR exchange rate). This plan is currently progressing with an expanded the rail link from Hotazel in the Kalahari belt to the Ngqura port with plans to utilise the existing berths. Transnet aims to set rail tariffs at sustainable levels to ensure South Africa's competitiveness is maintained.

Exhibit 2: Proposed increase in manganese ore transported by Transnet as per 2012 MDS plan



Source: Transnet

As it stands we remain unconvinced that Transnet can deliver on its proposed increases due to both political and financing uncertainty. While it seems relatively certain that the Ngqura port can be used to export volumes we think it will be up to the South African producers to try and maximise their allocation.

Manganese ore miners in SA have also flagged the potential for unutilised capacity on the Saldanha-Sishen iron ore export corridor, which has a nameplate capacity of 62Mt, to become available in future.

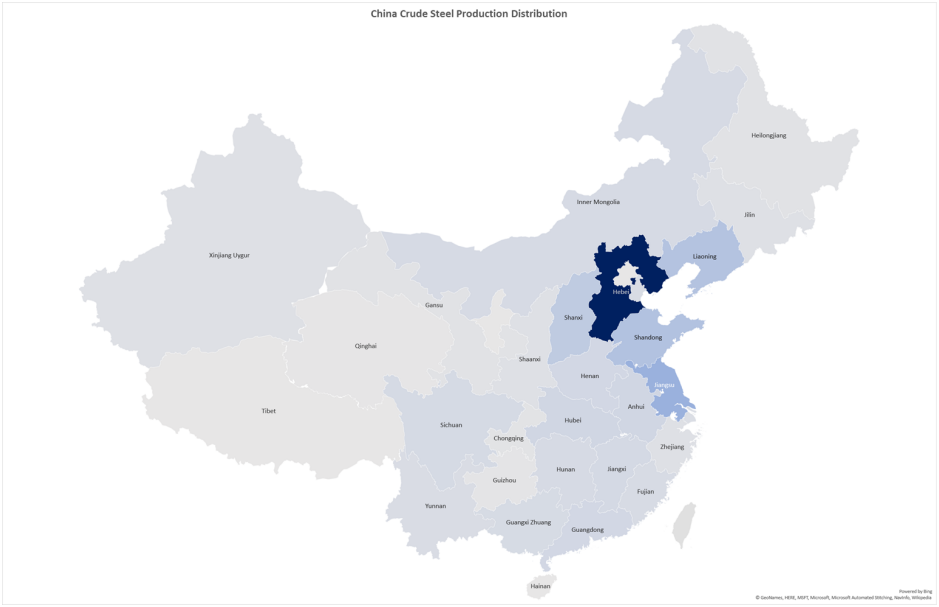
Chinese steel drives demand

China remains a key driver of global steel trends producing and consuming roughly 50% of global steel annually. We have forecasted China at "peak" steel demand for a number of years, yet steel demand continues to surprise to the upside. China steel production surprised positively in 2019 as Chinese policy makers have responded to weaker export demand, due to global trade tensions, with domestic property and infrastructure stimulus. We model steel production up 6.8% YoY in 2019. We do expect China steel demand growth to peak in 2019 yet expect utilisation rates to remain >85% even as demand growth slows. China's continued focus to act rationally when it comes to steel supply, plus the growing theme of industry consolidation in that market, should help underpin global steel spreads.

China dominates the global steel market, producing and consuming c.50% of steel globally driven in turn by construction and infrastructure spending. In 2018, China accounted for 62% of global manganese ore demand.

As of end-FY18, the top 5 steelmaking provinces (areas) in China were Hebei (237.3mnt or 25.6%), Jiangsu (104.3mnt or 11.3%), Shandong (71.8mnt or 7.8%), Liaoning (68.7mnt or 7.4%) and Shanxi (53.9mnt or 5.8%). The chart below displays the crude steel production distribution across the nation (Darker colour indicates the higher production). It can be seen that crude steel production is quite concentrated around the nation's capital Beijing.

Exhibit 3: China Crude Steel Production Distribution as of end-FY18



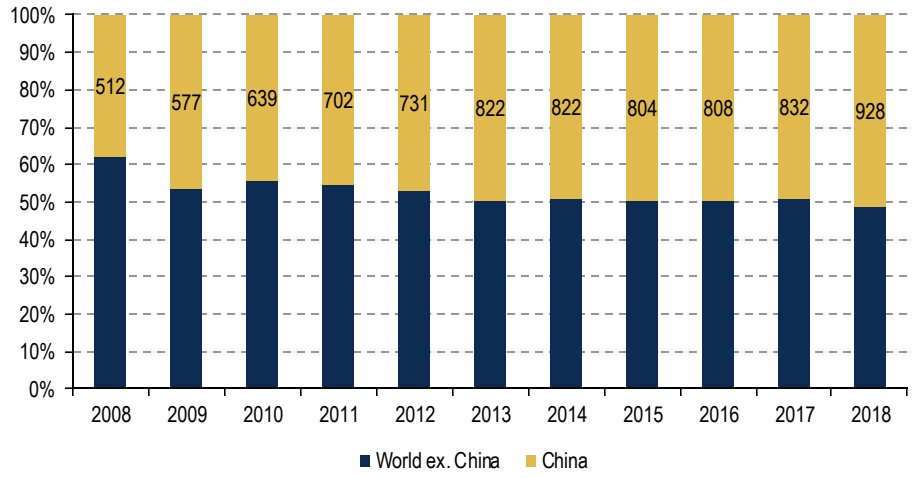
Source: NBS, BofA Merrill Lynch Global Research estimates
Note: Provinces / Areas with crude steel production have been listed in the map. *Darker blue indicates higher crude steel production.

Supply side reform in the Chinese steel industry

Supply side reform has become the most important theme in steel industry since FY16 for China and even for the world as China is the biggest producer across the globe. We observe strong determination of China's government and effective execution so far, not only in excessive capacity cuts, but also in environmental constraints.

In November 2018, more stringent regulation was imposed on Chinese steel mills. Steel mills were required to cease production of 355-Mpa tensile strength rebar in favour of 600Mpa-tensile rebar. Manganese alloys are key in the steelmaking process to improve tenacity and we thus included increased forecasts of ore imports into China by +2.6 – 3.0Mt till 2023 (32Mt).

Chart 9: China crude steel production in Mt and as % of world production



Source: World Steel Association, BofA Merrill Lynch Global Research estimates

Key factors to consider when assessing steel supply outlook in China

- Supply side reform policy: how will the market consolidation to play out in FY19-20E; whether illegal MFF operations will resurge (governments still push forward checks on such operations from time to time)
- Production suspension on environmental protection, which is highly related with the air quality in those 'sensitive' areas: Beijing-Tianjin-Hebei, Yangtze Delta Area, Pearl Delta Area etc., likely leading to unexpected production losses
- Capacity swap & relocation: need to monitor if such programs could be strictly implemented, and total capacity will be controlled or reduced
- Ramp-up of EAF: mills margin at producers using EAF really matters, and due to the nature of higher cost compared with traditional mills utilizing blast furnaces, they are more price/margin sensitive

Key indicators to consider when assessing steel demand outlook in China

- China's property new starts, sales, inventory and policy stance;
- Infrastructure FAI and construction activities;
- Machinery/equipment production trend and mining companies capex plan;
- China's auto sales and steel intensity change;
- Home appliance production and inventory;
- Industrial production and PMI trends;
- Overall GDP trends

Manganese 101

Manganese: What it is and main uses

Manganese is a naturally occurring substance that is the 12th most abundant element in the Earth's crust, and the 4th most used metal in the world (after iron, aluminium and copper). Pure manganese metal is silver in colour, and occurs naturally combined with other elements such as oxygen, sulphur, and chlorine.

Ore can be of three types: (a) high grade ore (42-48% manganese), (b) mid-grade ore (34-38% manganese) and (c) low grade ore (< 30% manganese).

Exhibit 4: Manganese metal

Source: WikiCommon

Exhibit 5: Manganese ore

Source: South32 company reports

Manganese is an industrial metal which is predominantly used as an alloy in the production of carbon and stainless steel. It requires c. 3 tonnes of ore per tonne of alloy produced. The purpose of adding manganese to the steel manufacturing process is to neutralize the negative effects of sulphur on the strength of steel. All steels contain manganese, generally 7kg-10kg per ton steel. Demand for manganese is therefore closely tied to steel production, with 80-90% of the material used for this purpose. In the case of stainless steel manganese can be used to substitute more expensive nickel in certain stainless grades.

Manganese alloy application in steel making

In the process of steelmaking, removing excess sulphur from the hot metal is key to creating high-quality, structural steel. Steelmakers rely on manganese reagents to produce the top-quality steel demanded by the building industry. Manganese alloys can also be used in the manufacture of other long-product steels like rails.

There is no viable substitute for manganese as a de-sulphuriser. Manganese can be used to improve the strength of certain steels (structural steels, high strength flat steels). Manganese is added to steel in order to:

- Deoxidize the steel (remove oxygen from the steel).
- De-sulphurise the steel (sulphur causes steel to crack).
- Influence the strength, toughness, and hardness of the steel.

Other non-metallic uses:

While 80-90% of manganese is used to produce manganese alloys used in steel making, other non-metallic applications include:

- **Potassium permanganate (KMnO4):** used as a disinfectant, in deodorant, and as bleaching and analytical reagent.
- **Manganese sulphate (MnSO4):** used as fertiliser, especially in citrus fruit production, and as a reducing agent in the manufacture of paint and varnish driers.
- **Manganous oxide (MnO):** used as a raw material in the production of manganous salts, additives in fertilisers, and a reagent in textile printing.
- **Manganous chloride (MnCl2):** used as catalyst in the chlorination of organic compounds and as an additive to animal feed.
- **Manganese dioxide (MnO2):** used in dry cell batteries, as a chemical oxidant in organic synthesis, and as a raw material in chemical-grade manganous oxide.

Types of manganese products

There are two primary types of manganese products: 1) Manganese ore and 2) Manganese alloys.

- **Manganese ore:** mined as primary ore. Different grades exist namely high grade ore (42-48% manganese), mid-grade ore (34-38% manganese) and low grade ore (less than 30% manganese).
- **Manganese ferroalloys:** produced using manganese ore (c.3t ore per ton alloy) Added to steel to increase strength these fall into three main categories:
    - High-carbon ferromanganese (HCFeMn)
    - Refined ferromanganese (MCFeMn);
    - Silicomanganese (SiMn, inc. low-carbon silicomanganese LCSiMn).

Table 3: Typical chemical composition of manganese ferroalloys

	Mn (%)	Si (%)	C (%)	P (%)	S (%)	B (ppm)
HC FeMn	74–78	0.3	7.5	0.2	-	-
Refined FeMn (MCFeMn)	80–83	0.6	0.5-1.5	0.2	-	-
SiMn	67	14-20	1.5-2	0.15-0.2	0.02	200
LCSiMn	59–63	26-31	0.05-0.5	0.1	0.01	100

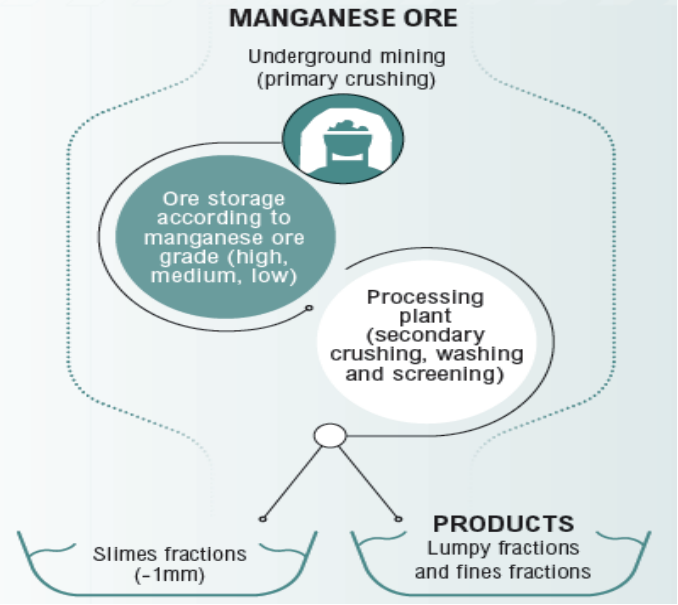
Source: BofA Merrill Lynch Global Research

From ore to alloy:

Manganese ore is mined, primarily through underground crushing, stored according to ore grade (high, medium or low) and processed into different products at a processing plant.

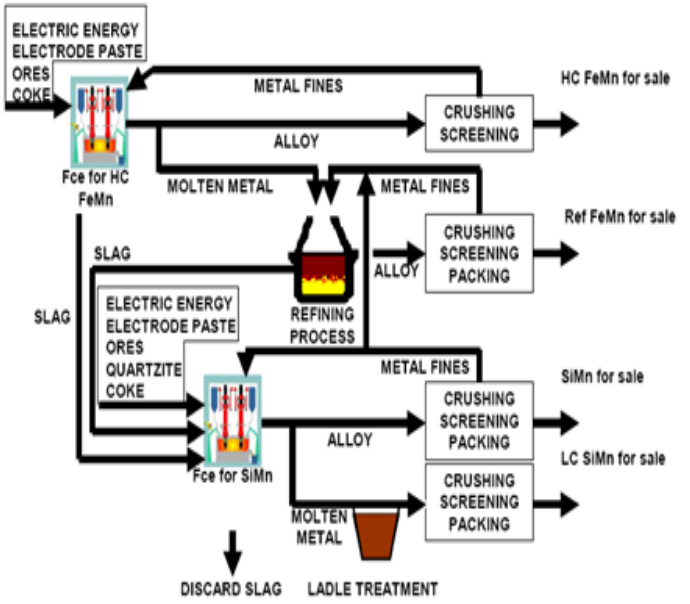
To produce manganese alloys from ore, an Electric Arc Furnace (EAF) is used. There is an additional stage, called ladle treatment that can be used to produce refined alloys, containing low levels of carbon. A blast furnace production process can also be used, but tends to be less popular and most widely used when producing HcFeMn alloys

Exhibit 6: Manganese ore: an overview



Source: ARM annual report 2018

Exhibit 7: Manganese alloy: EAF process



Source: Eramet company reports

Product pricing and price discovery

Manganese ore prices are closely tied to steel production, as demand for Mn is driven by steel production. Manganese ore and manganese alloy prices are highly correlated because manganese ore prices directly impact production costs for non-integrated, higher-cost alloys production.

Chinese buyers set the market clearing price as they consume c.50% of all the metal produced globally. This will then impact the prices realised by European buyers. We note manganese ore prices tend to lag manganese alloy prices by c. 6-12 months. This is because one is a raw material for the other, therefore reflecting the effects of stocking.

Manganese is not traded on the future markets, rather pricing is influence by physical supply and demand.

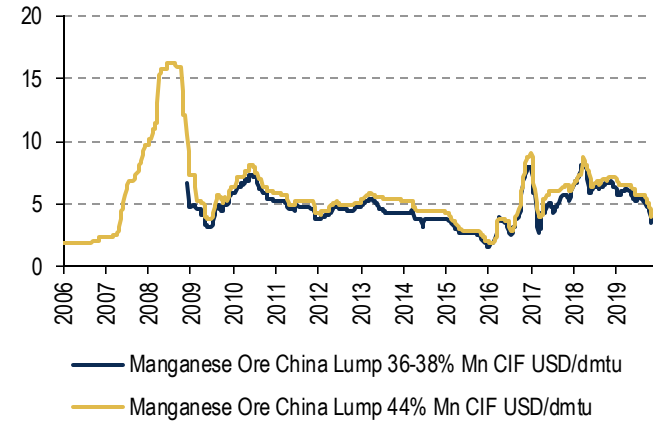
Manganese ore - US$/dmtu

Manganese ore prices are typically stated in US$/dmtu (dry metric ton unit). A dmtu corresponds to 10kg of manganese content. The prices vary according to the manganese grade in ore. Seaborne benchmarks are: 44% manganese ore CIF Tianjin and 37% manganese ore CIF Tianjin.

So just to be really explicit, a Gabonese ore (44%) priced at (say) US$5/dmtu should transact at about $220/t (on a dry basis i.e. which is then adjusted down to reflect moisture content). Compare this to other bulk commodities e.g. iron ore (c. $90/t), coking coal (c. $140/t) and thermal coal (c. $70/t). At the margin, high grade Manganese ore is worth more than other bulks and thus could be more amenable to higher cost transport solutions e.g. trucking. We see this with the marginal tonne of Kalahari product.

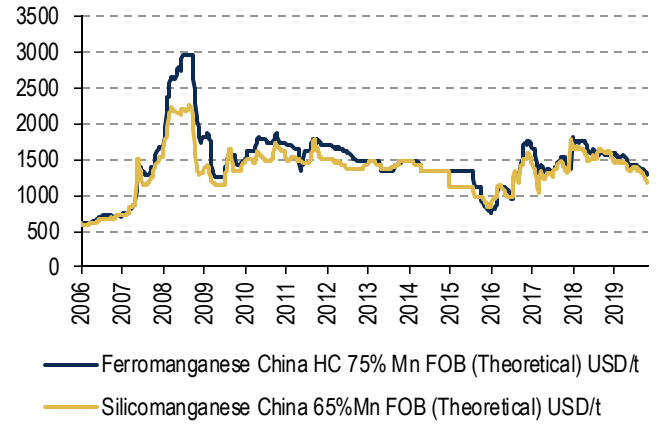
Historically, manganese ore was priced on an annual basis. However, due to increased demand and trading volumes, the ore prices are currently negotiated on a mix of spot and quarterly contract basis. We see an increasing shift in the pricing mechanism for manganese ores to a more spot market as has been the case with other bulk commodities.

Chart 10: Manganese ore pricing by grade in (US$/dmtu)



Source: BofA Merrill Lynch Global Research estimates

Chart 11: Manganese alloy prices by type (US$/dmtu)



Source: BofA Merrill Lynch Global Research estimates

Alloys – US$/t

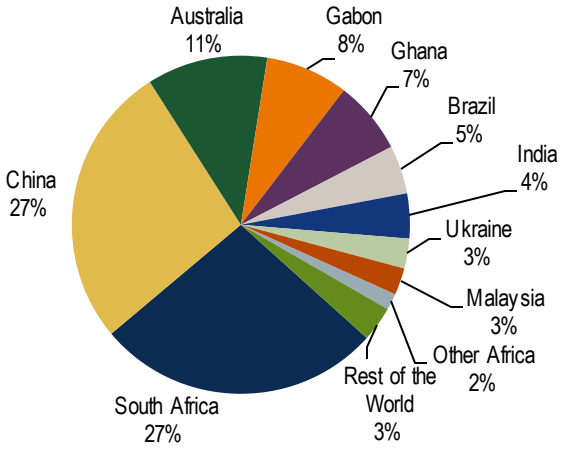
The prices for the various alloys groups vary according to their relative values in use. Refined alloys usually have higher selling price compared to standard alloys. Prices of manganese alloys are determined per gross ton of alloy and not per manganese content. However, the content is taken into consideration during price negotiations.

Manganese alloys contracts are generally negotiated on a quarterly basis for scheduled sales and on the spot prices for non-scheduled sales. The spot prices are habitually related to the indices that are published by the many specialised periodicals that track price trends through manganese price surveys. In Europe, the prices are usually stated in EUR and outside Europe they are mostly stated is USD. Benchmark pricing has historically been based off settlements with European buyers.

Manganese ore supply

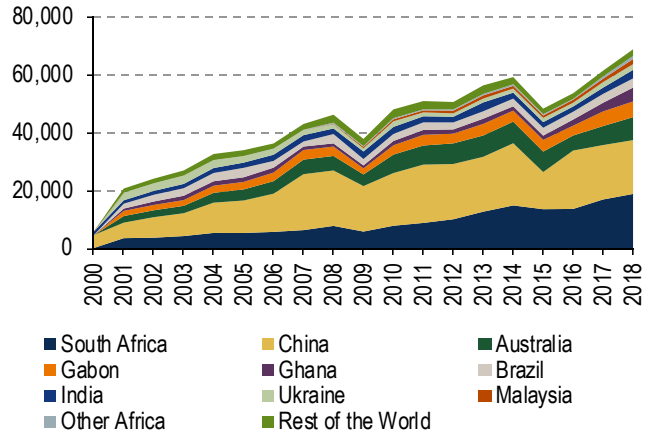
The major producers of manganese ore are China, South Africa, Australia and Gabon who together produced 73% of all manganese ore globally in 2018 (gross tonnes basis). In terms of reserves, the US Geological Survey estimates South Africa accounts for c. 74% and Ukraine 10% of the worlds identified manganese resources in a 2019 publication. Other countries with substantial reserves are Australia, Brazil, India, China and Gabon.

Chart 12: Manganese ore production by region 2018



Source: CRU International; BofA Merrill Lynch Global Research

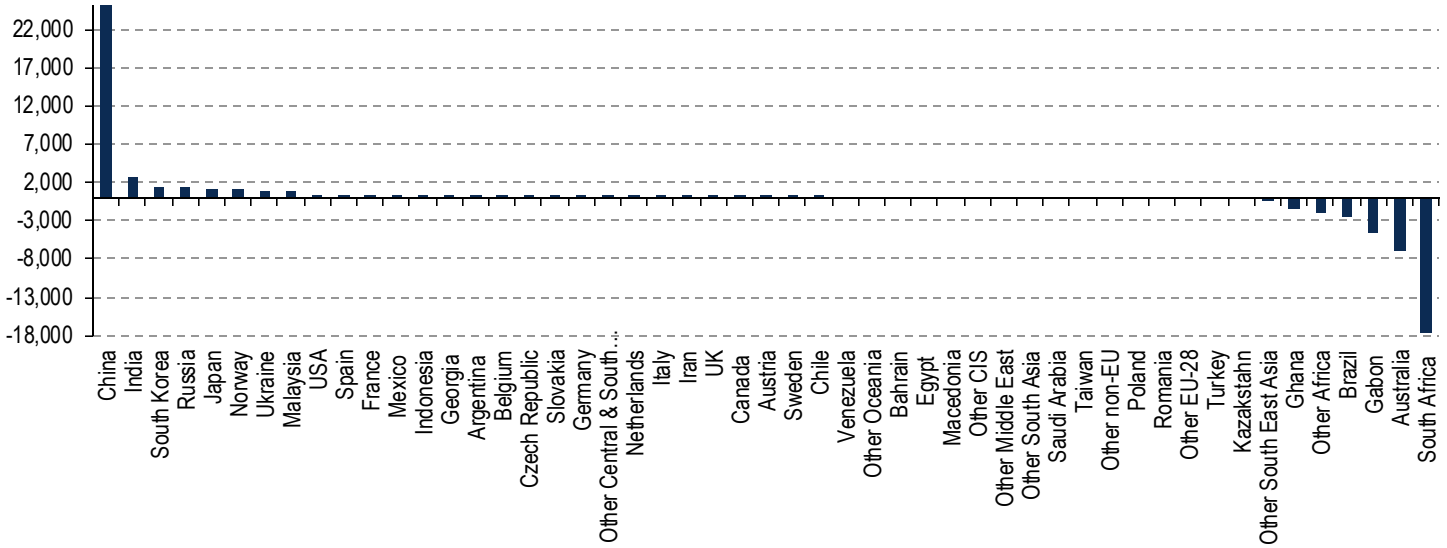
Chart 13: Manganese ore supply by origin over time (kt)



Source: CRU International; BofA Merrill Lynch Global Research

China is the largest producer of manganese ore (on a gross weight basis). Despite this, it is a net importer of ore to supply its domestic manganese alloy industry. South Africa, Australia and Gabon constitute over half of global Mn ore exports. China is set to remain the largest importer of manganese ore in the years ahead.

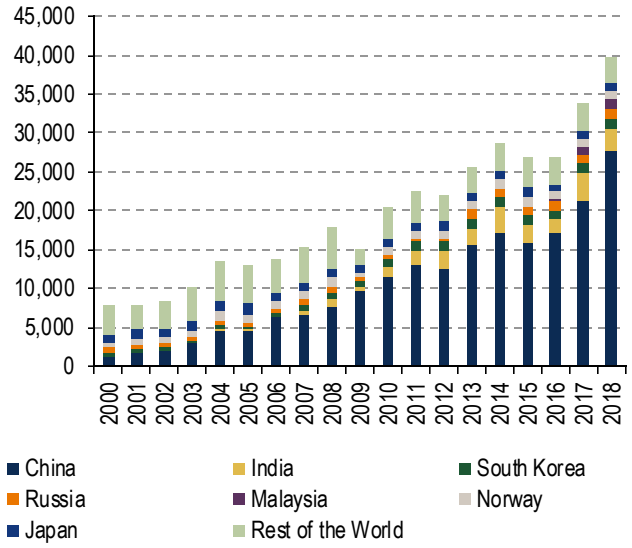
Chart 14: 2018 net import / (export) position for manganese ore globally in kt



Source: CRU International; BofA Merrill Lynch Global Research

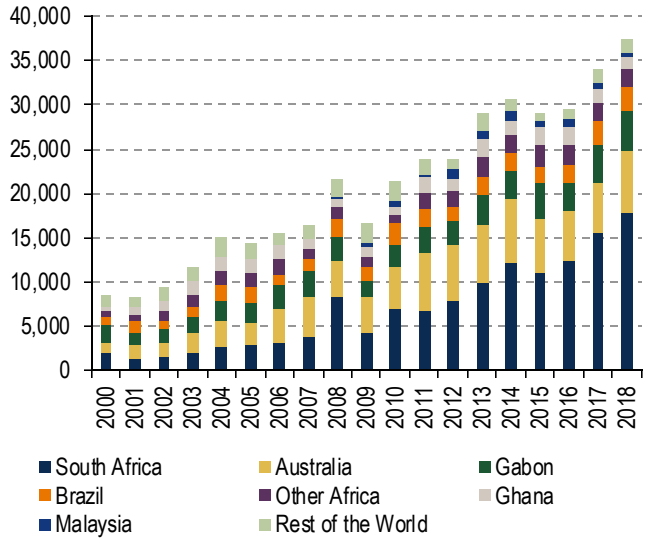
India has also emerged as a significant importer over the last 5 years due to the growth of its domestic alloys industry.

Chart 15: Global import market for manganese over time (kt)



Source: CRU International; BofA Merrill Lynch Global Research

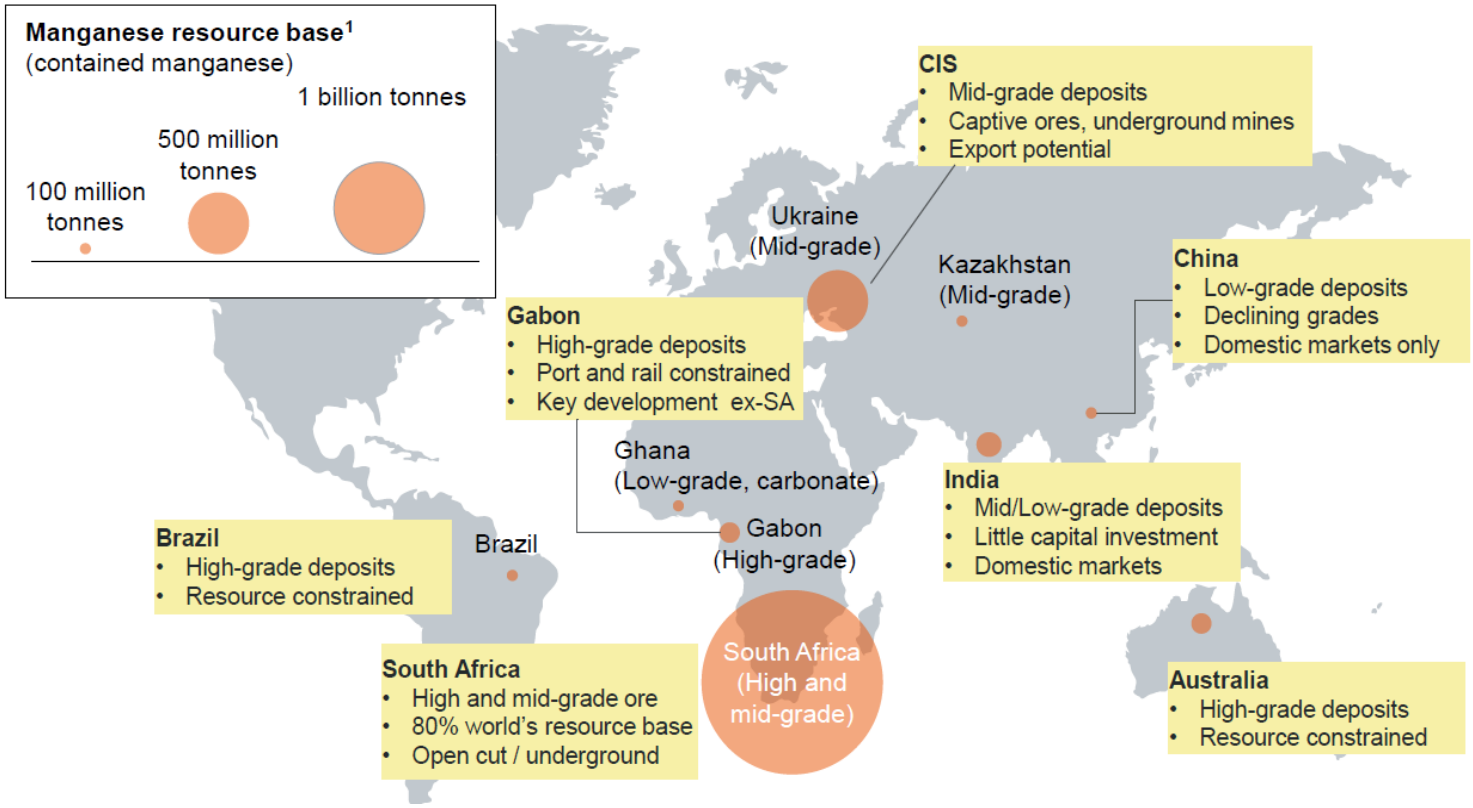
Chart 16: Global export market for manganese over time (kt)



Source: CRU International; BofA Merrill Lynch Global Research

In terms of global resource South Africa dominates holding c. 74% of global resources. The CIS also has significant resources albeit dominantly as captive ores at underground operations.

Exhibit 8: Overview of global manganese resource base by country with details on size and grade etc.



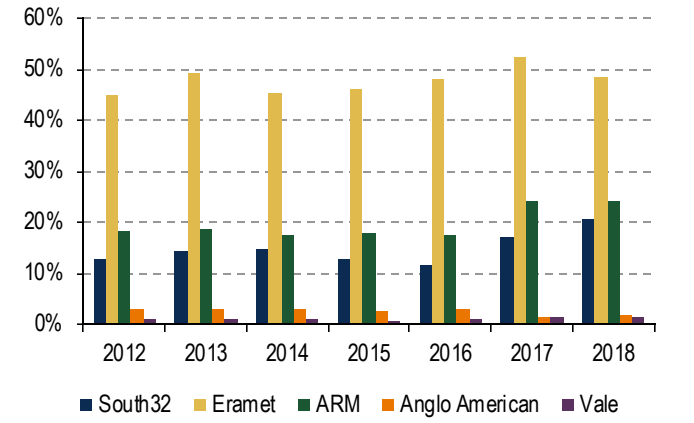
Source: South32 2016 company documents; Note 1) Defined by the US Geological Survey (USGS) as that part of an identified resource that meets specified minimum physical and chemical criteria related to current mining and production practices. The reserve base includes those resources that are currently economic (reserves), marginally economic (marginal reserves), and some of those that are currently subeconomic (subeconomic resources).

Manganese for global producers

The largest supplier of manganese ore by company are: Samancor Manganese (60:40 JV between South 32 and Anglo American), Eramet, and Assmang (50% ARM)

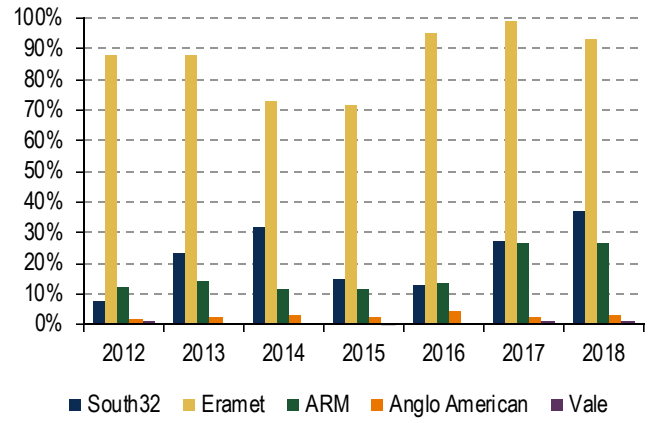
We consider the manganese exposure of listed miners. We then provide a brief overview of major manganese ore producers including South 32, Eramet, African Rainbow Minerals (ARM) and Anglo American.

Chart 17: Manganese as a % of Group Revenue



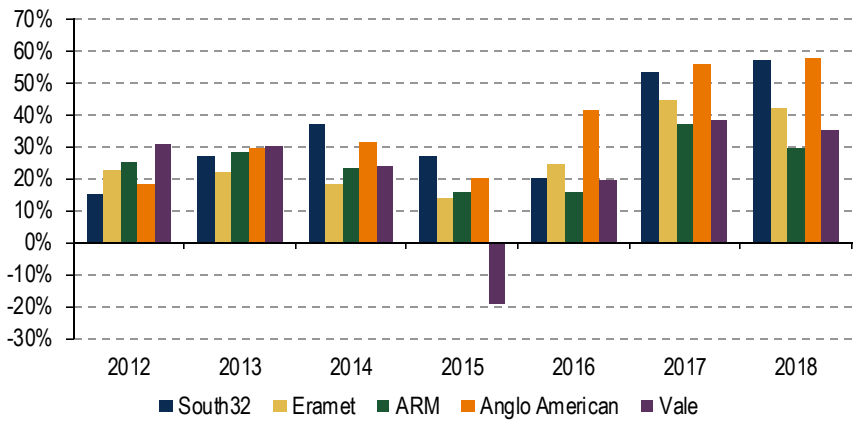
Source: BofA Merrill Lynch Global Research estimates

Chart 18: Manganese as a % of Group EBITDA



Source: BofA Merrill Lynch Global Research estimates

Chart 19: Manganese EBITDA Margin (as a % of Mn revenue)



ource: BofA Merrill Lynch Global Research estimates

South 32 – c.12% of world production

South 32's manganese assets are held through a 60% interest in Samancor (60:40 JV with Anglo American). The assets are located in Australia and South Africa. S32 was spun off from BHP in May 2015 along with nickel, thermal coal and aluminium assets.

South African Manganese

Samancor's assets in South Africa include Wessels and Mamatwan, located in Hotazel, Northern Cape. Both the mines are owned by Hotazel Manganese Mines (HMM). S32 has a 60% interest in Samancor with Anglo American holding the remaining 40%. S32's effective interest in HMM is 44%. Samamcor operates these two mines.

South 32 produces manganese alloy at Metalloys near Vereeniging in Gauteng and has a 51% interest in Manganese Metal Company, a producer of electrolytic manganese metal located in Nelspruit, Mpumalanga. South African manganese assets have mine life c.57 years.

Australian Manganese

Manganese ore is produced at Groote Eylandt in the Northern Territory (GEMCO) and manganese alloys in northern Tasmania (TEMCO), as part of Samancor Manganese. Combined capacity is 4.8Mtpa and c.70% of this output is exported. GEMCO's mine life is c.7 years.

Eramet – c.10% of world production

Eramet owns manganese mine, Moanda, in Gabon (Comilog – resource life of over 40 years) and various plants for processing ore. The division produces high-grade manganese ore, manganese alloys and chemical derivatives of manganese. Comilog is a subsidiary of Eramet (64% ERA, 29% Republic of Gabon). Manganese alloys are produced at seven plants located in China, Europe and the United States.

Eramet is currently extending Moanda to increase production volume to 7Mt by 2023 vs 4.5Mt in 2019. The extension project will include the development of the mine, construction of new facilities (washing, crushing, storage etc) and modernisation of some support facilities (increase in capacity of the port of Owendo).

Anglo American – c.8% of world production

Anglo American produced c.1.5Mtpa of manganese ore (contained Mn) through a 40% interest in Samancor Manganese in 2018. This formed c.8% of world production in 2018.

In South Africa, Anglo (via Samancor Manganese) participates in 2 manganese mines and an alloy smelter. The open-cut Mamatwan mine started operating more than 50 years ago, with the underground Wessels mine following a few years later.

In Australia, Samancor owns Groote Eylandt Mining Company (GEMCO) and Tasmanian Electro Metallurgical Company (TEMCO).

African Rainbow Minerals (ARM) – c.4% of world production

ARM's manganese division forms a part of ARM's Ferrous division (iron ore, manganese and chrome), which is held by way of a 50% investment in Assmang. The remaining 50% in Assmang is held by Assore Limited. The manganese assets consist of the Nchwaning and Gloria mines, the Machadodorp and Cato Ridge Ferromanganese works. The group also has a 50% interest in Cato Ridge Alloys, a JV between Assmang (50%), Mizushima Ferroalloys Company Ltd (40%) and Sumitomo Corp (10%).

Both the manganese mines have a life of mine of more than 15 years. Cato Ridge has the capacity to produce 18ktpa of HC FeMn and 80ktpa of refined FeMn.

These assets are jointly managed by ARM and Assore. While ARM provides administration and technical services, Assore performs the sales and marketing function and technical consultancy.

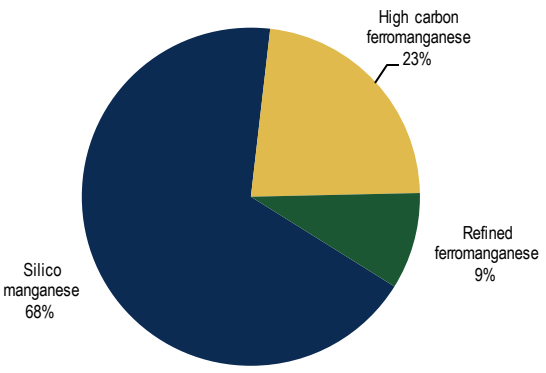
The company also has Sakura, a US$328m greenfield alloy project in Malaysia that was completed last year. The smelter is a joint venture with China Steel Corporation and Sumitomo Corporation.

Manganese ore demand

Manganese ore demand is driven by the production of manganese alloys and metal, which is in turn almost entirely driven by the consumption of steel.

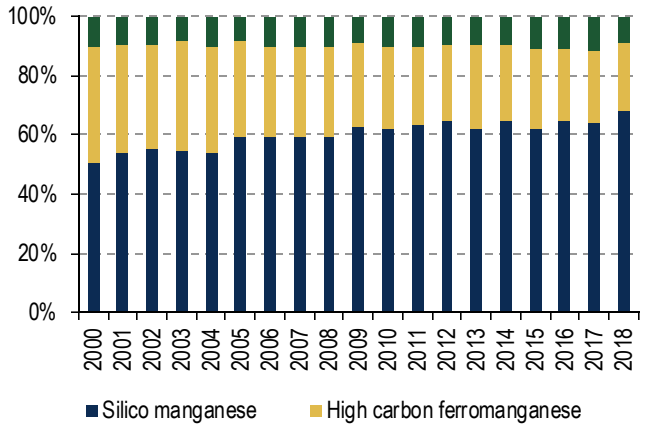
There are 3 main types of manganese alloys: 1) Silicomanganese, 2) high carbon ferromanganese and 3) refined ferromanganese. Electrolytic Manganese Metal (EMM) is also used in certain specialist carbon steel applications & alloying agents in place of high nickel for production of 200-series stainless steel. It is also used in other sectors like chemicals, electronics, aluminium and welding.

Chart 20: Share of manganese ore demand 2018



Source: CRU International

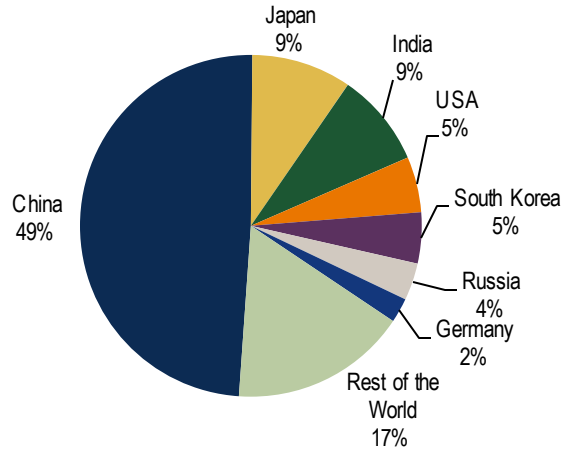
Chart 21: Share of manganese ore demand over time



Source: CRU International

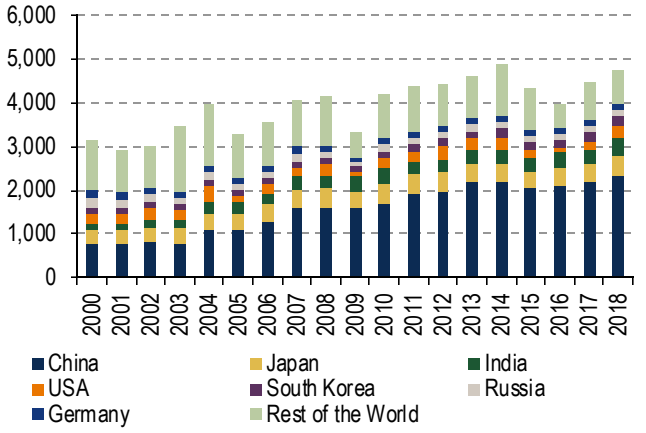
China is the largest consumer of manganese ore with its share of global consumption going from 56% in 2010 to 49% in 2018. We think China will continue to play a dominant role in the determination of demand and prices for manganese ore in the coming years. How much of this material is imported will depend on Chinese production and its cost competitiveness versus new supply. We expect Chinese domestic production of manganese ore to decline going forward.

Chart 22: Regional share of overall Mn ore demand 2018



Source: CRU International

Chart 23: Regional share of overall Mn ore demand over time



Source: CRU International

China steel: Demand growth outlook flattish

China produces and consumes more than 50% of global carbon steel per annum with demand driven largely by property and infrastructure spending. We forecast flattish Chinese carbon steel demand growth over 2019 – 2020. Steel demand from the property and infrastructure (c.50% of total Chinese steel demand) should grow in 2019 and 2020.

Table 4: Chinese steel demand model

	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
China pig iron output	202.3	251.9	330.4	404.2	469.4	470.7	543.7	590.2	629.7	657.9	709.0	712.0	691.4	700.7	710.8	771.1
China crude steel production - NBS reported	**222.3**	**282.9**	**353.2**	**419.1**	**489.3**	**503.1**	**572.2**	**637.2**	**685.3**	**723.9**	**779.0**	**822.7**	**803.8**	**808.4**	**831.7**	**928.3**
% YoY growth		*27.2%*	*24.9%*	*18.7%*	*16.7%*	*2.8%*	*13.7%*	*11.4%*	*7.5%*	*5.6%*	*7.6%*	*5.6%*	*-2.3%*	*0.6%*	*2.9%*	*11.6%*
Total China crude steel production incl. MFF effect									**711**	**751**	**808**	**853**	**844**	**868**	**872**	**928**
% YoY growth										*5.6%*	*7.6%*	*5.6%*	*-1.1%*	*2.9%*	*0.4%*	*6.5%*
Blast furnace									614	659	721	773	755	760	770	837
EAF									71	65	58	50	49	48	61	91
MFF									26	27	29	31	40	60	40	0
Per capita output of steel kg/capita	**173**	**218**	**271**	**320**	**371**	**380**	**430**	**476**	**528**	**555**	**594**	**624**	**614**	**628**	**627**	**664**
China finished steel production	210.8	255.5	324.4	383.6	451.7	469.4	545.2	605.8	675.9	713.7	769.3	810.7	801.6	824.9	828.1	872.6
Net exports	**30.2**	**15.0**	**5.3**	**-24.5**	**-45.9**	**-43.8**	**-7.0**	**-26.1**	**-33.3**	**-42.2**	**-48.3**	**-79.3**	**-99.6**	**-95.3**	**-62.1**	**-56.2**
China net finished steel production	**241.1**	**270.6**	**329.7**	**359.1**	**405.8**	**425.6**	**538.2**	**579.7**	**642.6**	**671.5**	**721.0**	**731.4**	**702.0**	**729.7**	**766.0**	**816.4**
China demand for finished steel from crude	**239.9**	**246.7**	**324.0**	**362.8**	**411.4**	**423.6**	**533.9**	**569.1**	**615.6**	**639.4**	**693.0**	**703.0**	**663.1**	**671.7**	**727.7**	**816.9**
% YoY growth		*2.8%*	*31.3%*	*12.0%*	*13.4%*	*3.0%*	*26.1%*	*6.6%*	*8.2%*	*3.9%*	*8.4%*	*1.4%*	*-5.7%*	*1.3%*	*8.3%*	*12.3%*
Steel demand crude equivalent	258.0	271.0	347.0	388.0	440.0	453.0	565.0	599.0	648.0	673.0	728.0	740.0	698.0	707.0	766.0	869.0
Per capita consumption of finished steel	**186**	**190**	**249**	**277**	**312**	**320**	**401**	**425**	**476**	**492**	**531**	**536**	**511**	**529**	**552**	**585**
Installed base of finished steel per tonnes/capita	2.04	2.24	2.47	2.73	3.01	3.31	3.69	4.10	4.54	5.00	5.50	5.98	6.42	6.87	7.34	7.84
Total crude capacity	**263.8**	**340.1**	**423.8**	**472.5**	**610.3**	**644.0**	**717.8**	**800.3**	**863.3**	**970.0**	**1073.9**	**1083.9**	**1063.9**	**1043.9**	**1022.1**	**1045.7**
BF			368.3	407.3	517.5	546.1	632.8	710.6	755.6	866.3	968.2	978.2	968.2	948.2	906.3	914.0
EAF			53.0	58.3	100.9	81.6	85.0	89.7	107.7	103.7	105.7	105.7	95.7	95.7	115.7	131.7
Net capacity additions/closures		76.3	83.6	48.7	137.8	33.7	73.8	82.5	63.0	106.7	103.9	10.0	-20.0	-20.0	-21.9	23.6
Total crude capacity (incl MFF capacity)							**0**	**0**	**913**	**1030**	**1134**	**1164**	**1164**	**1164**	**1022**	**1046**
Average utilization rate crude steel (NBS reported)	***84%***	***94%***	***92%***	***94%***	***90%***	***80%***	***84%***	***84%***	***82%***	***79%***	***76%***	***76%***	***75%***	***77%***	***81%***	***90%***

Source: BofA Merrill Lynch Global Research estimates

Table 5: Chinese demand by segment

	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
Property	147	171	183	236	241	283	260	235	256	276	310
%YoY	3.0%	16.1%	6.8%	29.2%	2.1%	17.7%	-8.2%	-9.8%	9.0%	7.7%	12.4%
Infrastructure	57	89	103	108	119	127	137	142	154	157	165
% YoY	0.7%	55.5%	15.4%	5.4%	9.7%	7.0%	8.2%	3.6%	8.1%	2.5%	4.9%
Machinery	104	130	147	161	172	173	164	155	151	156	161
%YoY	-2.5%	24.2%	13.1%	9.9%	6.7%	0.7%	-5.3%	-5.8%	-2.3%	3.4%	3.1%
Auto	13	20	24	25	27	32	34	35	39	41	39
% YoY	0.6%	47.2%	20.5%	4.9%	9.1%	17.4%	7.3%	2.9%	10.1%	4.2%	-3.8%
Appliance	6	7	8	9	10	11	12	11	12	12	11
% YoY	-6.4%	13.2%	17.1%	18.5%	12.0%	9.5%	5.3%	-1.8%	1.7%	4.0%	-12.3%
Shipbuilding	18	20	26	27	27	25	25	25	21	23	21
% YoY	9.8%	7.3%	34.2%	2.8%	1.0%	-8.7%	1.3%	-2.0%	-17.3%	10.5%	-7.4%
Other	77	98	79	75	70	70	101	100	100	103	110
% YoY	12.9%	27.6%	-19.5%	-5.9%	-6.3%	0.6%	43.1%	-0.8%	0.1%	3.1%	6.8%
Total demand % YoY	**3.0%**	**26.1%**	**6.6%**	**8.2%**	**3.9%**	**8.4%**	**1.4%**	**-5.7%**	**1.3%**	**8.3%**	**12.3%**

Source: BofA Merrill Lynch Global Research estimates

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Underperform	N/A	≥ 20%

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