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West and Central African iron ore development and its impact on world prices*

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The focus of the paper is on the potential of iron ore supplies from West and Central Africa to enter the export market over the short and medium terms and how this could impact the supply-side capacity and market price. To assess this, three export development scenarios (low, medium and high risk) are constructed for 17 iron ore mines (over 27 production expansion projects) in West and Central Africa. The projections for African iron ore are compared with the latest medium-term import forecasts and suggest that the development of West and Central African iron ore has the potential to create significant downward pressure on the price of iron ore exports over the medium term. The increased export capacity could push marginal producers – mainly in China but also in India and elsewhere – out of the market.

Key words: Africa, iron ore, market development, market outlook, mineral economics.

1. Introduction

The price of iron ore has reached historically high levels in the past 5 years as exporters have been unable to expand production fast enough to keep pace with China's booming steel demand. This situation has drawn China's domestic iron ore producers into the market despite having operating costs estimated at three times those of the established international exporters.

Over the coming 5 years, China is expected to increase its demand for iron ore imports at a steady but slowing rate as it attempts to correct significant structural problems with its economy. Predictions of China's continuing growth have led to a recent push by major exporters, juniors and investors to explore, expand and develop iron ore resources in established and emerging regions.

The push to expand global export capacity and the willingness of Chinese investors and banks to provide funding to projects in high-risk areas, such as West and Central Africa, has created a scenario where export capacity could significantly outgrow demand at its current price in the next 5 years. This oversupply will have consequences for the profitability of the iron ore

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industry and for economies heavily invested in the current boom such as Australia and Brazil.

Understanding the potential for development of Africa's iron ore riches is of high importance to iron ore-rich countries such as Australia. For example, high prices and expanding iron ore production have been an important element in Australia's recent economic success, reflected in its historically high terms of trade. In 2011–2012, iron ore exports are forecast to increase by 2 per cent to A$59.7 billion, compared with 2010–2011 (BREE 2012). However, there is scant analysis of the potential of West and Central African iron ore to supply Chinese import demand, and how this could impact the industry worldwide or in Australia specifically.

This paper attempts to assess the current state of the iron ore market and predictions for the medium term, with a focus on the potential of West and Central African iron ore-rich countries. The paper is set out as follows: first, the medium-term forecasts are outlined for the major importers and exporters; next, the paper discusses the rising commercial prospects of several iron ore-rich countries in Africa and the important ties developed with Chinese partners; third, by constructing a risk index for mine and expansion projects, the paper forecasts the export potential of West and Central African iron ore-rich countries. Finally, the impact of Africa's expanding export potential on the iron ore price and profit margins is discussed. The paper concludes by outlining the key findings.

2. Background

The most important use of iron ore (up to 98 per cent) is as a primary input to steel production. There is no current substitute for iron ore in blast furnace steel production, and it takes approximately 1.6 tonnes of iron ore to produce one tonne of steel. Blast furnace production accounts for around 69.8 per cent of global steel production technology and 90.2 per cent of China's production (World Steel Association 2011).

2.1. Demand forecast

China is experiencing a period of unprecedented economic growth, which has put significant strain on the global iron ore industry to expand to keep pace with supply. When China joined the WTO in 2001 iron ore sold for around US$12.68/t. Since then, its rapid industrialisation, emerging middle class and urbanisation have contributed to unprecedented growth of demand of China's steel industry – this was the main driver for the export price reaching the historic high of US$187.18/t in February 2011 (see Figure 1).

The Australian government's Bureau of Resource and Energy Economics (BREE) estimates that to satisfy the needs of its growing economy and the accompanying demands of its emerging middle class, continuing urbanisation and industrialisation, China's steel consumption will grow from 657 mt in

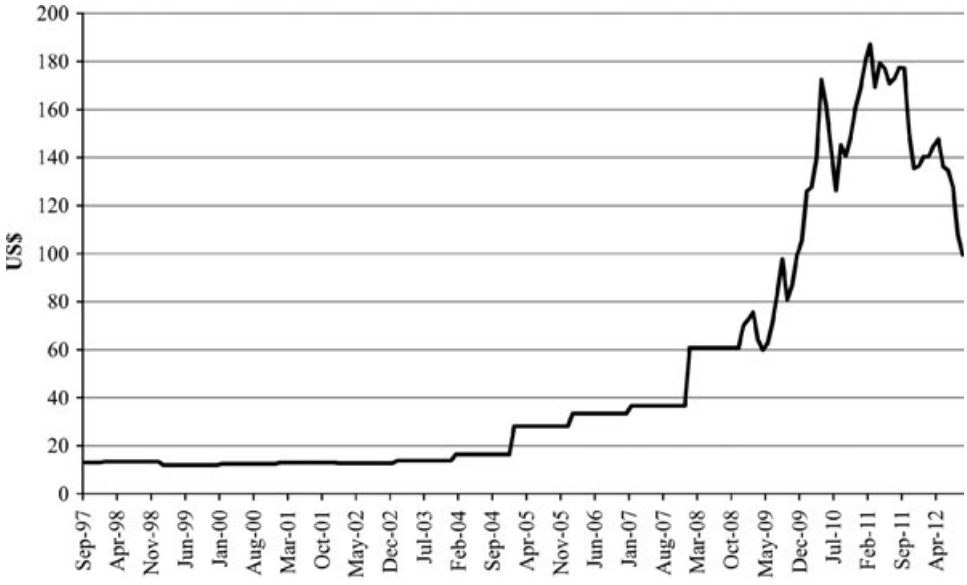

Figure 1 Iron ore price, 1997–2012. Source: Indexmundi.com (2012).

2012 to 812 mt in 2017 – accounting for 52.5 per cent of global expansion of steel consumption over this period (see Table 1) (BREE 2012).

Despite large reserves, the average grade of China's iron ore is low (generally around 30 per cent ferric content), and reserves are predominantly located in the country's north and west, making transportation costly to steel mills, which are located mainly in industrialised coastal southern provinces (Drysdale and Hurst 2012). The rise of China has outpaced the expansion of exporters, and China's marginal iron ore producers supplied an estimated 38.8 per cent of China's iron ore to its domestic steel mills in 2010.

China's marginal producers face costs of around US$120/t – around US $80/t more than established producers of high-grade (generally around 62 per cent) iron ore in Australia and Brazil – making imports a more reliable and

Table 1 Global crude steel consumption outlook, 2010–2017 (mt)

	2010	2011	2012	2013	2014	2015	2016	2017
European Union	160	164	164	166	168	171	173	176
United States	90	94	96	98	101	104	107	110
Brazil	30	31	32	34	35	36	37	38
Russian Federation	42	44	45	47	48	50	52	53
China	600	624	657	695	729	761	787	812
Japan	68	69	74	77	78	80	81	83
Korea, Rep. of	55	56	57	59	61	64	66	68
Chinese Taipei	21	24	25	25	26	26	27	28
India	66	76	82	88	95	101	107	113
World steel consumption	1389	1450	1508	1575	1639	1694	1745	1803

Source: BREE (2012).

cost-effective solution for China's steel industry (Trench 2004; Tse 2012). BREE's (2012) forecast indicates that iron ore exports to China will continue to grow at around 2.8 per cent per annum between 2012 and 2017 (a total increase of around 141 mt over the period) (see Table 2).

2.2 Supply response

BREE (2012) predicts that global demand for iron ore imports will increase by 425 mt from 2011 to 2017 (around the size of Australia's total iron ore exports in 2011) – of this increased demand, Chinese steel mills will account for around half (209 mt).

Iron ore export expansion will be led by Australia's and Brazil's big four exporters (Vale, Rio Tinto, BHP Billiton and Fortescue) as Indian exports recede in face of the recently imposed 30 per cent iron ore export tariff and China's domestic iron ore producers face rising domestic inflation, continued exchange rate appreciation and decreasing international freight rates (UNCTAD 2011) (see Table 3).

2.2.1. India: domestic supply focus

As Australian and Brazilian iron ore producers rush to meet rising demand from China, India is set to cut exports dramatically. In 2010, India was the world's third largest iron ore exporter, capturing around 9.1 per cent or 96 mt of the global export market (BREE 2012).

In 2011, Indian authorities adopted policies to ensure their rapidly emerging middle class, and urban infrastructure needs would be supported by Indian steel production, in turn served by India's own iron ore riches. On 2 January 2012, the Indian government announced a further increase in export tariffs to iron ore lumps and fines of 30 per cent.

Unless the Federation of Indian Mineral Industries is able to have the tariffs repealed, exports for the first quarter of 2012 could be 75 per cent lower than that previously expected (BREE forecasts a drop in exports from 63 mt in 2011 to 43 mt in 2012) (Mukherjee and Dutta 2012).

The gap left by receding Indian exports will put upward pressure on international prices in the short term and further support the case for rapid expansion of the export industry in Australia and Brazil (de Krester 2012).

Table 2 World iron ore imports, 2010–2017 (mt)

	2010	2011	2012	2013	2014	2015	2016	2017
European Union	133	136	139	142	144	146	149	152
Japan	134	128	134	136	138	140	142	143
China	619	645	713	742	757	770	813	854
Korea, Rep. of	56	64	67	72	75	78	80	83
Chinese Taipei	19	22	23	23	24	25	25	26
World imports	1051	1075	1149	1213	1279	1355	1439	1500

Source: BREE (2012).

Table 3 Iron ore exports, 2010–2017 (mt)

	2010	2011	2012	2013	2014	2015	2016	2017
Australia	402	439	493	525	588	678	749	779
Brazil	311	313	333	372	411	443	467	489
India	96	63	43	46	46	46	44	40
Canada	33	34	36	37	37	38	38	38
South Africa	48	54	58	64	67	71	75	79
West Africa†	11	12	14	15	17	23	35	47
World exports	1051	1075	1149	1213	1279	1355	1439	1500

†West Africa includes Guinea and Mauritania.
Source: BREE (2012).

2.2.2. Australia: expansion plans and magnetite potential

Australian producers have developed significant expansion plans to capitalise on the rising demand from China and diminishing Indian exports. Currently, around US$60.8 billion of investments is planned for new iron ore mines and to expand current capacity, with another US$22 billion earmarked for infrastructure projects to support new capacity – these investments are scheduled to occur by 2018. The expansion plans are led by the three big Australian iron ore producers (BHP Billiton, Rio Tinto and Fortescue) as they attempt to push the total seaborne iron ore trade from 439 mt/a in 2011 to over 779 mt/a by 2017 (BREE 2012).

High-grade haematite, or direct shipping ore (DSO), has driven Australia's iron ore boom to date. But the recent historically high prices and accompanying profit margins for iron ore have brought Australia's vast magnetite deposits into consideration in expansion plans (Game-Lopata 2012).

Australia currently has around 60 magnetite mines in planning or operational phases with total magnetite resources estimated at around 24.1bt (see Table 5). A report published by Deloitte Access Economics in 2011 estimated that development of the magnetite industry could add A$4.5 billion to national GDP per annum and create more than 4000 jobs (Burrell 2011).

Just as Japan's development and engagement was critical to unlocking Australia's Pilbara haematite reserves in the 1960s, China is now well positioned to partner magnetite projects (Siddique 2011). For example, Sino Iron's CITIC Pacific Magnetite Project is a significant step for the budding industry and is set to become the largest magnetite operation in the world; at full capacity, CITIC Pacific will mine around 140 mt per annum. But cost overruns and delays have resulted from a lack of understanding of Australia's policy environment more broadly – a key assumption underpinning the project was the cost savings CITIC hoped to gain from importing Chinese engineers and workers to build the mines. When standard Australian restrictions on imported labour were discovered by CITIC, the budget blew out significantly.

As of 2011, Chinese investors have suspended all investments in magnetite projects in Western Australia (Hurst and Wang 2012).

2.2.3 Brazil: expansion plans and cost reduction

Brazil is the second largest global iron ore exporter. Led by Vale, Brazil's exporters are investing quickly to take advantage of the high price of iron ore. BREE (2012) forecasts that iron ore exports from Brazil will reach 489 mt in 2017, up from 313 mt in 2011 (see Table 4).

Vale will invest US$10.2 billion by 2014 to expand its iron ore mine Carajás Serra Sul. Carajás, in the northern state of Pará, is the site of the company's single largest iron ore mine. Vale will also invest US$2.5 billion by 2014 in the Apolo iron ore mine project in Minas Gerais.

Australian producers hold a cost advantage over their Brazilian counterparts due to their geographic proximity to China. In December 2011, Capesize shipping rates from Port Hedland/Dampier to Qingdao are around US$13.50 per tonne (3 458 nautical miles), whereas Brazilian exporters faced transport costs of US$30.50 per tonne from Tubarão to Qingdao (11 023 nautical miles). Capesize ships from Australia take around 22 days 12 hours less time to reach Qingdao (based on 13 knot shipping speed) (see Figure 2).

Table 4 Australian magnetite potential

State	Planned mines	Total magnetite raw (mt)
WA	29	17,846.6
SA	25	6048.8
Tas	3	61.2
Qld	2	137.4
NT	1	3.7
Total	60	24,097.7

Source: Intierra database.

Table 5 Highlights from FOCAC conferences, 2000–2009

Year (Location)	Highlights
2000 (Beijing)	Participants from 44 countries passed the *Programme for China–Africa Cooperation in Economic and Social Development*
2003 (Addis Ababa)	Under the Addis Ababa Action Plan China wrote off $1 debt for thirty-two African countries
2006 (Beijing)	Heads of state or government from 35 African countries. China pledged US$5 billion in concessionary loans
2009 (Sharm el-Sheik)	Heads of state from 49 African governments. A new US$10 billion concessionary loan and a US$1 billion loan for small- and medium-scale African businesses China pledged construction of 100 new clean energy projects and increased support for medical and education projects

Source: Sparks (2011).

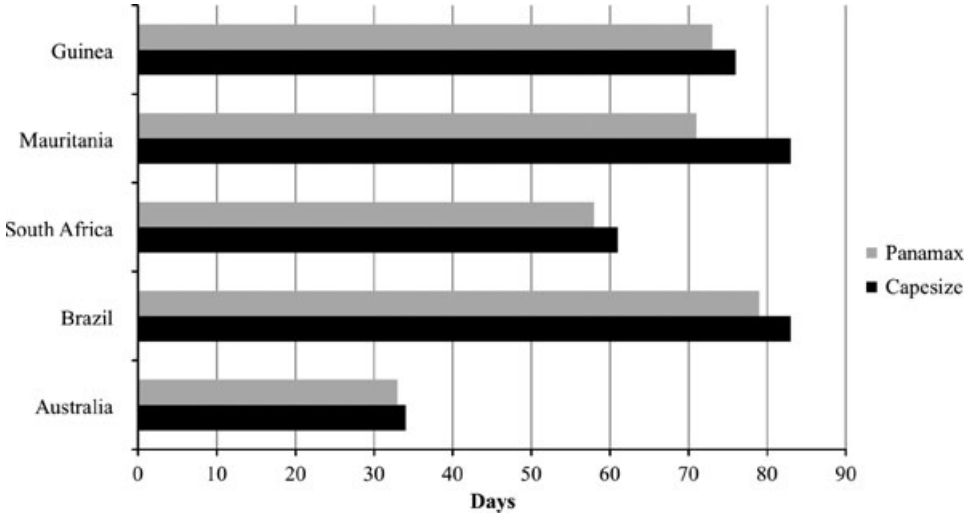

Figure 2 Vessel roundtrip days to China, including congestion and bunkering. Source: Ocean Ocean Equities (2011).

In an attempt to diminish the cost advantage of Australian producers, Vale has pursued an aggressive US$8 billion strategy to have 35 Valemax ships built. The Valemax ships can carry 380 000 to 400 000 deadweight tonnes (dwt) of iron ore each – more than twice the capacity of the current Capesize vessels, representing around US$1.6-2 million saving per shipment. The project has met significant obstacles, such as a cracked ballast tank in one ship and being turned away from Chinese ports, but it is too soon to accurately assert its success or failure.

3. West and Central Africa: the new iron ore frontier

Africa's total iron ore reserves (measured plus inferred) contain an estimated 34.9bt of haematite and 17.3bt of magnetite (see Appendix 1). In comparative terms, Africa has similar reserves to Australia, with 37.0bt of reported haematite reserves and 10.4bt of magnetite, although reserve levels provide a limited insight into production potential.

The forecast demand growth for iron ore from China and diminishing grades of haematite in Australia and Brazil, along with the uncertainty surrounding India's iron ore exports, have seen the focus shift to Africa's iron ore industry as low operating costs, and vast, high-grade discoveries of haematite have overshadowed countries' risk profiles.

The key driver for Africa's growth is not just China's booming resource import demand, but improved political and macroeconomic stability and microeconomic reforms. In the past decade, the real GDP of iron ore-rich African countries has enjoyed a healthy growth rate of 4.0 per cent (average GDP growth across Cameroon, Republic of Congo, Guinea, Liberia,

Senegal, Sierra Leone, Gabon) – the global average for the period was 3.9 per cent (McKinsey & Company 2010).

The improved business environment has benefitted from government debt relief for the most highly indebted countries. Increased pledges of overseas development assistance from donor countries and philanthropic institutions are also providing fresh opportunities to free up resources for investment in human and fixed capital (Donnelly and Ford 2009).

This growth and other political and macroeconomic indicators suggest that Africa may be at a turning point as a global resource supplier. Guinea's Bellzone and China International Fund joint venture operating company Forécariah Guinea Mining is an example of how high-risk operations in Africa's are becoming realistic investment opportunities. The project is set to begin exporting iron ore to China in the first quarter of 2012, on schedule (Esterhuizen 2012).

The draw of Africa's iron ore is its relative purity. As ferrous content decreases in Australia and Brazil, unearthed African deposits consistently offer DSO quality resources. But for decades, the main obstacle to investing in African mining has been insufficient – often nonexistent – infrastructure. Deals that might have looked good on paper were often unviable once the infrastructure costs were factored into the internal rate of return. This situation means that the initial marginal cost for West and Central African iron ore will be massive when compared to the marginal costs of expanding production in Australia and Brazil where infrastructure is developed.

3.1. Sino-African cooperation

To develop African resources, Chinese operators have support from the US$5 billion China–Africa Development Fund (CADFund). The CADFund's stated aim is, 'Investing directly in Chinese enterprises which have set up operations in Africa or plan to invest in Africa, CADFund will push Chinese and African enterprises to reach their cooperation targets and facilitate infrastructure construction, as well as enhance the social and economic development of African countries'. The Fund provides equity and quasi-equity investment, fund investment and investment management and consulting services for projects in agriculture, manufacturing, infrastructure, natural resources and industrial parks.

In addition to infrastructure development support, China's renewed investment push into global markets may hold the key for the development of African iron ore. RBC Capital Markets (2011) reports all-in capital costs to develop a sample of 32 iron ore mine sites across the African continent range between US$52 billion and US$54 billion. Current credit ratings for African iron ore countries (see Appendix 2), coupled with western banks' unwillingness to invest in such projects, suggest that it is unrealistic to expect these resources will develop in the next 5 to 10 years. An Australian mining CEO explained:

> The difference is that the Chinese operators can get the funding from Chinese banks where the Western banks won't lend… So the Western company might make their assessment and go, 'Yeah, I want to buy', but can't get any funding for it and that's the difference.

Moran *et al*. (2012) stated that 'Chinese investors will be more willing to take on new frontier – or even fringe – projects that the major established oil and mining companies might pass by'. Moran (2010) noted that in 13 of 16 cases analysed, Chinese investors took an equity stake and/or wrote long-term procurement contracts with producers on the competitive fringe.

Looking to the future, China has the necessary capital to assist the development of African iron ore export capacity in a way that will relieve supply pressure. China's Ministry of Commerce (MOFCOM) announced in early 2012 that over the next 5 years, it will encourage ODI to increase global stocks to US$560 billion (an increase of US$390 billion over the period). This push aims to make better use of China's estimated US$3.5 trillion of foreign exchange reserves at a time when exports markets are declining and FDI inflows slowing down as a result of the global economic crisis (Edwards 2012; Huang 2012).

This future Chinese ODI is not all earmarked for African iron ore projects. But if 14 per cent of the $390 billion ODI is directed to African iron ore projects over the next 5 years, it would meet the $52–54 billion all-in capital costs reported by RBC Capital Markets to develop 32 mines across the continent.

It is essential for African governments to ensure a supportive business environment for these major capital intensive projects. Chinese banks are able to take a longer-term view of projects in comparison with western lenders, but the Chinese authorities are cracking down on risky investments in the wake of significant and embarrassing losses on international projects. China's State Assets Supervision and Administration Commission published new rules in 2012 that hold SOEs and their executives accountable for bad overseas investment decisions (Cai 2012).

Low levels of knowledge capital have also been a considerable obstacle for the development of technology intensive infrastructure and mine sites. Again, China is a promising partner on this front. Unlike Australia, most of Africa's resource-rich countries allow Chinese operators to import a wider range of labour and management. Although this has created cases of significant tension and difficulties, it is a key ingredient for Africa's iron ore development, which had been previously lacking.

China's aim to secure iron ore supplies in Africa is supported by long-established state relationships, fostered through its triennial Forum of China–Africa Cooperation (FOCAC) (see Table 5 for FOCAC highlights).

Strong state ties provide some assurance and political insurance for Chinese investment in iron ore. China's noninterventionist approach to

international engagement also permits relationships with regimes where western governments would be unwilling (Hurst 2010).

3.2. Supply potential

Already there are hundreds of iron ore projects under study or being developed in Africa, with governments pushing to increase their iron ore export capacity, while the price is high. For example, the Guinean government has pressured Rio Tinto to truck iron ore 650 km to meet its first ore shipment deadline of mid-2013 from its Simandou mine.

3.2.1. Method

The author collected data for 27 mine and expansion projects, which are planned across West and Central African. Each project was assessed for risk using a seven-factor risk index to construct three risk-based scenarios – high, medium and low-risk. Risk was calculated by considering data from a number of sources (such as company reports, Intierra database and news articles) on host operational risk, host political risk, project infrastructure requirements, investor experience, investor-government relations, funding risks and Chinese ownership and funding. Each project received a numerical overall score for risk based on the unweighted aggregated scores for the seven risk categories and assigned an overall risk rating of high, medium or low risk based on the overall score.

Another way of looking at these risk scenarios is to think of low-risk projects as having a high probability of coming on stream as designed and within the time frame planned; medium- and high-risk expansion phases have a lower probability of meeting their outlined initial production dates, being more likely to be delayed. The likelihood of these higher-risk projects coming online in the long-term is nonetheless real, and they represent a significant longer-term overhang in the market (see Appendix 3 for list of mine and expansion projects).

3.2.2. Results

Based on the reporting of 17 mines (more than 27 production expansion phases), West and Central African iron ore production has the potential, in the high-risk scenario, to add 481 mt/a to world iron ore export capacity by 2018 (see Figure 3 and Table 7). This figure is in line with estimates by RBC Capital Markets (2011) that 475–575 mt/a of iron ore export capacity will become available in Africa by 2016 (based on analysis of 32 mines), and by Ocean Ocean Equities (2011) that 300 mt/a could be available by 2018 (based on 16 mines).

The low-risk scenario suggests that if all high- and medium-risk projects are delayed beyond 2018, 31 mt/a (in addition to the 425 mt of already forecast global export supply expansion) will come online by 2018 – representing a global export supply overcapacity of 2 per cent. If all medium- and low-risk

projects are successful and high-risk projects delayed, 166 mt/a export capacity could come online – representing 10.6 per cent export overcapacity by 2018. If all 27 analysed mine and expansion projects come online as planned, an extra 422 mt/a would be available to the global export market by 2018. This increase would see export capacity 27 per cent greater than forecast global demand by 2008 (see Figures 3 and 4, and Tables 6 and 7).

Most disclosed estimates of operating costs for West and Central African iron ore projects tend to be relatively low due to low labour costs and the

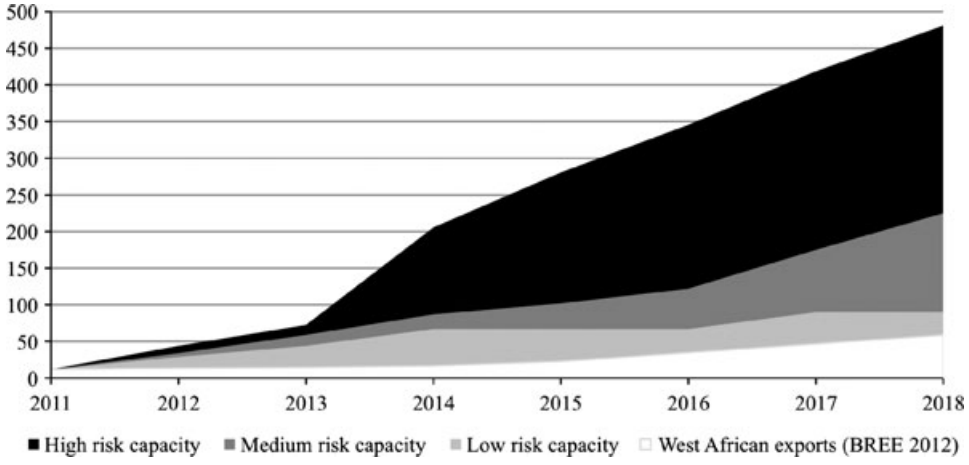

Figure 3 Potential West and Central African iron ore export capacity scenarios, 2011–2018 (mt/a). Sources: BREE (2012); Intierra database; RBC Capital Markets (2011); Ocean Ocean Equities (2011); company reports; author's calculations.

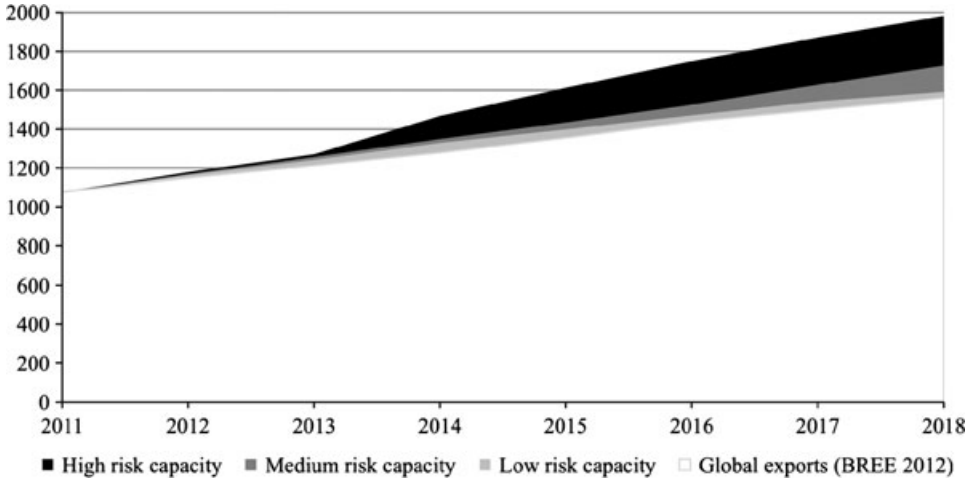

Figure 4 Potential global export capacity scenarios, 2011–2018 (mt/a). Sources: BREE (2012); Intierra database; RBC Capital Markets (2011); Ocean Ocean Equities (2011); company reports; author's calculations.

Table 6 West and Central African export capacity scenarios, 2011–2018 (mt/a)

	2011	2012	2013	2014	2015	2016	2017	2018†
BREE (2012) West African forecast	12	14	15	17	23	35	47	59
Low-risk capacity	0	15	29	50	44	32	43	31
Cumulative additional capacity	12	29	44	67	67	67	90	90
Medium-risk capacity	0	5	15	20	35	55	85	135
Cumulative additional capacity	12	34	59	87	92	122	175	225
High-risk capacity	0	10	13.6	118.6	178.6	223.6	243.6	256
Cumulative additional capacity	0	44	72.6	205.6	270.6	345.6	418.6	481

†BREE forecast import growth for 2010–2017 has been extrapolated linearly for 2018.
Note: Rio Tinto's Simandou mine capacity is assumed to come online as 5 mt (2013), +5 mt (2014), +10 mt (2015), +15 mt (2016), +30 mt (2017), +30 mt (2018) in the medium-risk scenario.
Sources: BREE (2012); Intierra database; RBC Capital Markets (2011); Ocean Ocean Equities (2011); company reports; author's calculations.

Table 7 Potential global export capacity scenarios, 2011–2018 (mt/a)

	2011	2012	2013	2014	2015	2016	2017	2018
High-risk capacity	1075	1179	1270.6	1467.6	1612.6	1749.6	1871.6	1983
Export overcapacity	0.0%	2.6%	4.8%	14.8%	19.0%	21.6%	24.8%	27.0%
Medium-risk capacity	1075	1169	1257	1349	1434	1526	1628	1727
Export overcapacity	0.0%	1.7%	3.6%	5.5%	5.8%	6.1%	8.5%	10.6%
Low-risk capacity	1075	1164	1242	1329	1399	1471	1543	1592
Export overcapacity	0.0%	1.3%	2.4%	3.9%	3.3%	2.2%	2.9%	2.0%
Global exports (BREE 2012)	1075	1149	1213	1279	1355	1439	1500	1561†

†BREE forecast export growth for 2010–2017 has been extrapolated linearly for 2018.
Sources: BREE (2012); Intierra database; RBC Capital Markets (2011); Ocean Ocean Equities (2011); company reports; author's calculations.

high-grade ore, which requires little processing. African free on board (fob) cost estimates range from as low as US$20/t for the planned DSO material from Sundance's Mbalam project up to US$50/t for Sierra Leone's Marampa mine (RBC Capital Markets 2011; Emery 2012). When shipping costs are included, West and Central African iron ore will, on average, cost around A$50–80/t cif into China. Marginal cost for African projects will be much higher and has been accounted for in the risk index, which considers factors such as project infrastructure requirements.

In a business as usual scenario, BREE (2012) estimated that the contract price of iron ore will average around A$140/t in 2012 and will drop to A$109/t by 2017.

In the low-risk scenario, the addition of BREE's forecast global expansion and African export capacity could decrease the price to A$80/t cost, insurance and freight (cif) into China by 2018; the medium-risk scenario could see the price drop to around A$65/t, and the high-risk scenario, to around A$60/t (see Figures 5 and 6).

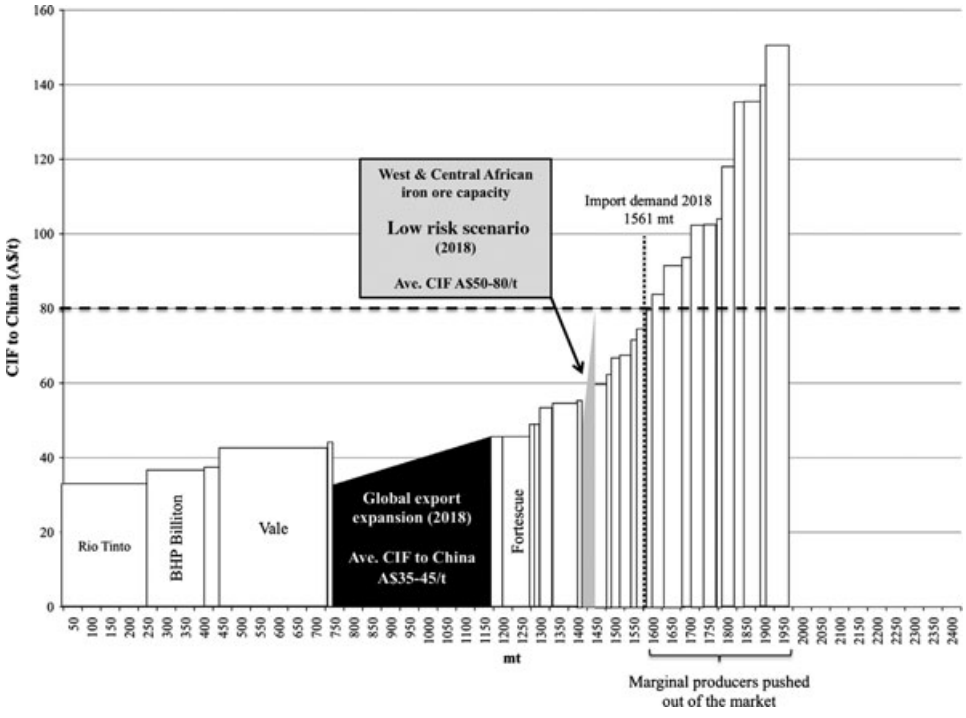

Figure 5 2010 iron ore cost curve with global export capacity expansion and low-risk Africa scenario (2018, CIF to China A$/t). SOURCES: Mackenzie (2011); BREE (2012); author's calculations.

In the low-risk scenario, West and Central African iron ore will push current marginal suppliers – mainly Chinese but also Indian and others – out of the market. If the high-risk scenario is realised some of the new higher cost, African capacity will also be pushed out.

If the iron ore price dropped to A$80/t cif into China, low-cost exporters such as Rio Tinto, BHP Billiton and Vale would still have a A$35–45/t margin. If the high- or medium-risk scenarios materialised, these operating margins could drop to around A$25–30/t.

4. Conclusion

The forecast growth of China's iron ore imports and India's focus on supplying its domestic steel industry over the medium term has led miners and investors to aggressively pursue exploration, expansion and development of Australian and Brazilian resources. But there has been a recent trend to look further afield to countries traditionally considered too risky.

Countries in West and Central Africa have vast and high-quality iron ore reserves, but development of these resources requires massive capital infrastructure investment in operationally risky environments. Western banks

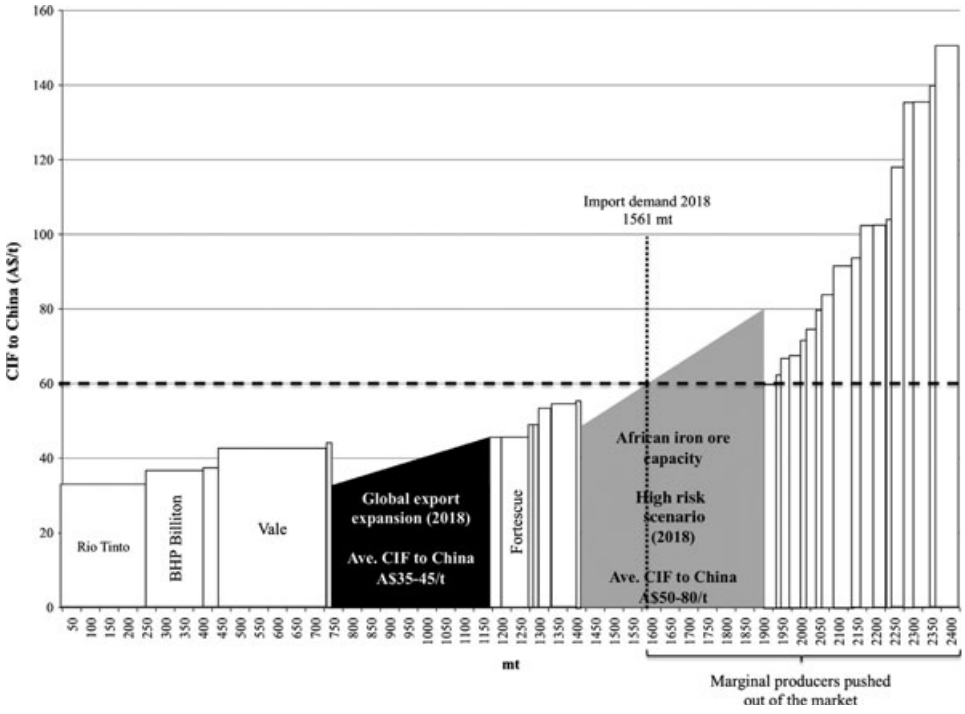

Figure 6 2010 iron ore cost curve with global export capacity expansion and high-risk Africa scenario (2018, CIF to China A$/t). Sources: Mackenzie (2011); BREE (2012); author's calculations.

are extremely hesitant to lend, and the scarcity of capital has been a large impediment to development.

China, on the other hand, has an estimated US$3.5 trillion in foreign exchange reserves, and state authorities have stated they will support US$390 billion in overseas direct investments over the next 5 years – much of which will target strategic resources such as iron ore.

China has also capitalised on its noninterference approach to international engagement and established state ties with several of Africa's iron ore-rich nations. This state-level engagement provides assurance to China's mainly state-owned investors and banks when making large capital investments in operationally risky projects. But in the light of recent overseas investment failures, Chinese authorities are requiring more rigour in due diligence, and African governments will be required to ensure their investment environment is supportive of the major capital projects required.

The push to expand iron ore export capacity in Africa along with African governments' pressure to get iron ore to market while the price is high has created significant risk of export overcapacity in the medium term. If all the iron ore projects analysed came online as reported, by 2018 an additional 481 mt/a will be available to the global export market – representing 27 per cent overcapacity in global exports. This could lead the price of iron ore to

drop to around A$60/t cif to China in the high-risk scenario – the price could fall to around A$65/t in the medium and A$80/t in the low-risk scenarios.

A price decrease to A$80/t would still provide intra-marginal producers like Rio Tinto and Vale with considerable yet highly impacted operating margins of around A$35–45/t – instead of current margins of over A$80/t. But the price decrease would push out marginal producers – especially in China but also in India and elsewhere.

This research provides a preliminary analysis of the potential for emerging iron ore-rich countries in Africa to build export capacity over the medium term and how that could impact the global market. Further research is required on the industrial organisation of the global iron ore market and analysis on how rents are shared between buyers and sellers; this will require careful analysis of the organisation and influence of the state in the Chinese steel market. Finally, there is value in developing a general or partial equilibrium framework to better understand the supply and demand variables influencing the iron ore market to establish long-run trends.

References

BREE (2012). Resource and Energy Quarterly. Bureau of Resource and Energy Economics, Canberra, March.

Burrell, A. (2011) Give us a chance, say magnetite miners. The Australian. Available from URL: http://www.theaustralian.com.au/business/companies/give-us-a-chance-say-magnetite-miners/story-fn91v9q3-1226130912552 [accessed 10 Dec 2011].

Cai, P. (2012) China takes a tougher line. Available from URL: http://www.brisbanetimes.com.au/business/china-takes-a-tougher-line-20120412-1wwin.html, *Brisbane Times* [accessed 14 April 2012].

Capital Markets, R.B.C. (2011). African iron ore projects: potential for new supply. RBC Prospector, February 4.

Donnelly, R. and Ford, B. (2009). Into Africa: How the Resource Boom is Making Sub-Saharan Africa More Important to Australia. Lowy Institute Paper 24, Lowy Institute, Sydney.

Drysdale, P. and Hurst, L. (2012) China's growth and its impact on resource demand and the iron ore trade. in The Brenthurst Foundation & Australian Strategic Policy Institute (eds), Fuelling the dragon: Natural resources and China's development, Special Report, Canberra, pp. 11–39.

Edwards, N. (2012). Politics, patchy past hurt China investment hopes. Reuters Available from URL: http://www.moneycontrol.com/news/wire-news/politics-patchy-past-hurt-china-investment-hopes_670642.html [accessed 22 Feb 2012].

Emery, K. (2012). Tonkilili ripple effect. The West Australian. Available from URL: http://au.news.yahoo.com/thewest/opinion/post/-/blog/13376306/tonkolili-ripple-effect/ [accessed 14 April 2012].

Esterhuizen, I. (2012). Guinea's First Commercial Iron-ore Mine on Schedule – Bellzone. Miningweekly.com, February 27.

Game-Lopata, A. (2012). Oakajee project to go ahead without Murchison, *Supply Chain Review*. Available from URL: http://www.supplychainreview.com.au/news/articleid/77576.aspx [accessed 12 Jan 2012].

Huang, Y. (2012). Outward direct investment, Chinese style, *East Asia Forum Quarterly* 4(2), 13–15.
Hurst, L. (2010). China and Africa: friends with benefits, *East Asia Forum Quarterly* 2(1), 20–1.
Hurst, L. and Wang, B. (2012). Australia's dumb luck and Chinese investment, *East Asia Forum Quarterly* 4(2), 32–33.
de Krester, A. (2012). India ore policy to benefit Australia, Australian Financial Review, January 4.
Mackenzie, K. (2011). China's iron ore imports mystery, solved…, *Financial Times*. Available from URL: http://ftalphaville.ft.com/blog/2011/12/15/798571/chinas-iron-ore-imports-mysterysolved/ [accessed 17 Dec 2011].
McKinsey & Company (2010). Lions on the Move: The Progress and Potential of African Economies. McKinsey Global Institute, Washington, DC. June.
Moran, T.H. (2010). China's strategy to secure natural resources: risks, dangers, and opportunities. Policy Analysis in International Economics, 92.
Moran, T.H., Kotschwar, B. and Muir, J. (2012). The Chinese overseas direct investment model: Chinese strategy toward natural resource procurement, *East Asia Forum Quarterly* 4 (2), 28–30.
Mukherjee, K. and Dutta, R. (2012). India iron ore exports seen plunging after tax rise. Reuters Online http://www.reuters.com/article/2012/01/03/india-ironore-idUSL3E8C34V920120103 [accessed 12 Jan 2012].
Ocean Equities (2011). Differentiating Amongst the African Juniors and Identifying the Next Serious Contenders. Iron ore sector update, July 7.
Siddique, M.A.B. (2011). Western Australia-Japan mining co-operation: an historical overview. The University of Western Australia Discussion Paper, 09.11.
Sparks, D.L. (2011). India and China's growing economic involvement in sub-Saharan Africa, *Journal of African Studies and Development* 3(4), 65–75.
Trench, J.G. (2004). Role of the Chinese steel industry in the economic development of China and Australia's contribution to the industry as a supplier of raw materials. PhD Thesis, Murdoch University, Perth.
Tse, P.-K. (2012). The Mineral Industry of China. U.S. Geological Survey Minerals Yearbook: 2010 [Advanced Release], U.S. Geological Survey, Washington, DC.
UNCTAD (2011). Trust Fund on Iron ore Information: Iron ore Market 2010–2012. United Nations Conference on Trade and Development, Geneva, July.
World Steel Association (2011). Steel Statistical Yearbook 2011. Worldsteel Committee on Economic Studies, Brussels.

Appendix 1 Potential haematite and magnetite reserves for African iron ore-rich countries

Country	No. of mines reporting	Unknown mine type	Total mines	Reported iron ore (mt)	Total (%)	Reporting mines	Mines operating	Other†	Reported magnetite raw (mt)	Total (%)	Reporting mines	Mines operating	Other
Algeria	4	1	5	132.00	0.38	2	2	—	2320.00	13.41	2	—	2
Cameroon	11	2	13	6960.80	19.92	9	—	9	3510.60	20.29	2	—	2
Congo (Rep. of)	4	8	12	5899.80	16.89	4	—	4	—	0.00	—	—	—
Guinea	4	10	14	2732.00	7.82	3	—	3	6160.00	35.60	1	—	1
Liberia	2	14	16	2174.00	6.22	2	—	2	—	0.00	—	—	—
Mauritania	5	5	10	270.00	0.77	2	2	—	3836.00	22.17	3	1	2
Nigeria	7	7	14	6378.00	18.26	7	1	6	—	0.00	—	—	—
Senegal	4	0	4	107.00	0.31	1	—	1	1067.00	6.17	3	—	3
Sierra Leone	7	10	17	2611.00	7.47	6	1	5	37.00	0.21	1	1	—
South Africa	10	15	25	3720.74	10.65	10	7	3	—	0.00	—	—	—
Other	24	58	82	3951.68	11.31	20	—	20	371.30	2.15	4	—	—
Total	82	130	212	34,937.02	100	66	13	53	17,301.90	100	16	2	14

Source: Intierra database (accessed 18 January 2012.

†'Other' refers to a mine with a status other than operational, that is, advanced exploration, construction, exploration, feasibility study, grass roots, prefeasibility/scoping and unknown.

Appendix 2 African long-term foreign currency rating (as of 28 November, 2011)

Country	S&P	Fitch
Cameroon	B	B
Congo, Republic of the	—	—
Guinea	—	—
Liberia	—	—
Mauritania	—	—
Nigeria	B+	BB−
Sierra Leone	—	—
South Africa	BBB+	BBB+

Appendix 3 African iron ore prospects, 2011–2018

Property name (phase)	Risk rating†
Tonkolili Iron Ore/Magnetite Operation (Phase 1)	Low
Faleme (Phase 1)	Low
Forecariah Iron Ore Deposit (Phase 2)	Low
Mayoko-Moussondji Iron Ore Project (Phase 1)	Low
Tonkolili Iron Ore/Magnetite Operation (Phase 2)	Low
Tonkolili Iron Ore/Magnetite Operation (Phase 3)	Low
Bong	Medium
Forecariah Iron Ore Deposit (Phase 1)	Medium
Kango	Medium
Simandou Iron Ore Project (Phase 1)	Medium
Kalia mine project (Phase 2)	Medium
Simandou Iron Ore Project (Phase 2)	Medium
Simandou Iron Ore Project (Phase 3)	Medium
Simandou Iron Ore Project (Phase 4)	Medium
Kalia mine project (Phase 3)	Medium
Simandou Iron Ore Project (Phase 5)	Medium
Simandou South (Zogota, Koni, Brikoidou) (Phase 1)	High
Marampa Magnetite Mine (Phase 1)	High
Kalia mine project (Phase 1)	High
Mbalam Iron Ore Project (Phase 1)	High
Simandou (Blocks 1&2) Iron Ore Project	High
Western Cluster (Mano River Iron Ore Deposits, Bomi Hills Iron Ore Deposits and the Bea Mountain Iron Ore Deposits (greenfield))	High
Avima Iron Ore Project	High
Simandou South (Zogota, Koni, Brikoidou) (Phase 2)	High
Zanaga	High
Putu	High
Marampa Magnetite Mine (Phase 2)	High

†Risk was calculated by considering data from a number of sources on host operational risk, host political risk, project infrastructure requirements, investor experience, investor-government relations, funding risks and Chinese ownership and funding.