The Impact of Supply and Demand Drivers on the Iron Ore Price and Cycle

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DECLARATION

I declare that this research report is my own, unaided work. It is submitted to the Degree of Master of Science in Engineering. I have read the University Policy on Plagiarism, and hereby confirm that no plagiarism exists in this report. I also confirm that there is no copying, nor is there any copyright infringement. I willingly submit to any investigation in this regard by the School of Mining Engineering and undertake to abide by the decision of any such investigation.

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ABSTRACT

Iron ore prices rallied from USD15/DMT during 2004 and experienced a significant drop from USD 140/DMT during the latter part of 2013. The purpose of the work is to identify the key drivers impacting on iron ore demand globally. Understanding the supply and demand balance and impact on price, is key to informed decision making relating to the iron ore business. The research methodology applied largely followed a quantitative methodology. Key drivers of iron ore demand, supply and demand balance and the impact on price were evaluated. The method applied consisted of gathering data from secondary sources and a detailed quantitative analysis on GDP, stage of economic development, steel consumption, supply and demand of iron ore and intensity of use.

Approximately 98% of all iron ore is used for steel making and on that basis steel consumption is the primary driver for iron ore demand. Steel is mostly used for construction and manufacturing and is driven by emerging economies of which China is currently the largest contributor. Global GDP growth correlates well with steel consumption and is primarily driven by emerging economies. Urbanisation was and still is a key driver for construction in China, to provide housing and related infrastructure for transportation and services. Scrap steel recycling, currently at 15%, affect the demand for new steel and indirectly iron ore. Iron ore is abundant and can easily meet the demand. The significant growth from 2004/5 to 2013/14 and the unprecedented demand for steel resulted in elevated iron ore prices, introducing high cost iron ore, predominantly from Chinese State owned companies. From late 2013, the iron ore prices reduced significantly. This was mainly due to the steel consumption in China slowing down; delivering of large scale, low cost iron ore projects in Australia and Brazil and a significant reduction in oil prices.

The key drivers impacting iron ore demand is: global GDP growth, industrialisation and urbanisation of emerging economies, recycling of steel, supply and demand balance of iron ore, the cost of production and the price of global iron ore. For the medium term outlook, the iron ore market will be structurally over-supplied and, as a result, the demand could be met at significantly lower cost of production levels than that seen during the period leading up to the price collapse in 2013. This is primarily

because of the increase in low-cost supply from the major suppliers displacing higher cost producers. China will continue to grow and drive the global demand for steel and iron ore during the medium term albeit at much lower rates when compared to the last decade. The demand for steel will increase until 2020 according to various analyst views. The iron ore prices are expected to trade between USD50/DMT to USD70/DMT from 2016 to 2020 mainly because of the over-supply situation and demand being mostly met by large scale, low-cost producers. The decision around the continuation of high cost, state owned Chinese iron ore producers, new large-scale low cost production and the oil price will impact on the price outlook.

DEDICATION

I give all the glory to God Almighty who gave me the strength throughout the assignment as without him this task would not have been possible. I dedicate this work to my loving wife, Michahn Nortje, for supporting and encouraging me during the past year. I thank her for understanding all the weekends and late nights working relentlessly on this research report and that she supported me throughout the process. In memory of my late father Johan Nortje, for being a fair, honest and hard-working man, who inspired me over the years.

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The conclusions and recommendations in the research report are those of the author and does not necessarily reflect the views of Anglo American.

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NOMENCLATURE

Bt	Billion tonnes
Btpa	Billion tonnes per annum
CFR	Cost and freight
CIS	Commonwealth of Independent States
DMT	Dry metric tonne
DRI	Direct reduction iron
DSO	Direct-shipping ore
EBIT	Earnings before interest and tax
EBITDA	Earnings before interest, tax, depreciation and amortization
Fe	Iron
FMG	Fortescue Metals Group
FOB	Free on board
GDP	Gross domestic product
GFC	Global financial crisis
IMF	International monetary fund
Mtpa	Million tonnes per annum
SIB	Stay in Business
UK	United Kingdom

USA	United States of America
USD	United States dollar
USGS	United States Geological Survey
WACC	Weighted average cost of capital
WWII	World War II

1 INTRODUCTION

1.1 Research background and context

The accelerated growth in China, as well as the stage of economic development, spurred a demand for commodities. It is suspected that the rapid increase in demand exceeded supply for a prolonged period and resulted in the rapid price escalation observed in Figure 1.1. This will be investigated as part of this project report.

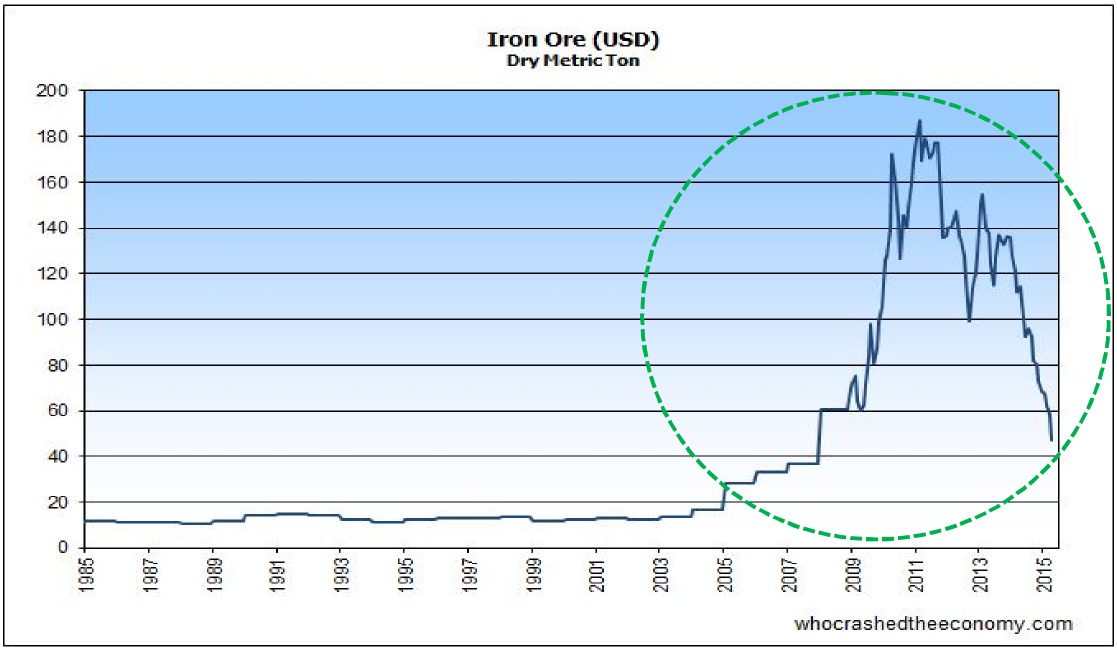

Figure 1.1: Iron ore price 1985-2015 (Admin, 2016)

As is typical in economics, the elevated prices from the late 2000s presented significant opportunities for companies to maximise earnings by increasing production, as well as opportunities for new entrants to the market. This resulted in major projects being built with large tonnages of iron ore making its way to the market to meet increasing demand, from China in particular. The largest iron ore producers, namely Rio Tinto (RIO), Vale, BHP Billiton (BHP) and Fortescue Metals Group (FMG) are testament to this fact. As per their annual reports, annual iron ore output from the four major producers increased by 348 Mtpa from 657 Mtpa in 2010 to 1.05 Btpa in 2015 over the five year period. During the period of 2010 to 2015, Vale increased output from 307 Mtpa to 346 Mtpa; BHP from 124 Mtpa to 232 Mtpa, RIO from 185 Mtpa to 263 Mtpa and FMG from 41 Mtpa to 164 Mtpa. Some of these companies increased output as a result of operational improvement programs and others from new/expansion projects such as Carajas expansion project, Jimblebar project and Cape Lambert expansion program. It is suspected that as a result of a slowing Chinese economy and a continued increase in supply from various producers, the market reverted to an oversupply situation with the prices dropping significantly.[1]

Figure 1.1 indicates the significant rise and fall of the iron ore price after a prolonged period of more than 20 years with the price being relatively flat. The price in Figure 1.1 is expressed in USD/DMT, fines 62% Fe, CFR China with various price periods easily identifiable and summarized as follows:

- For the period 1985-2004, the global iron ore price traded in a range of USD10-20/DMT.
- For the period 2005-2008, the global iron ore price increased significantly and traded in a range of USD30/DMT to USD40/DMT. The price effectively doubled over a period of four years.
- During 2008, there was a significant step change in price with the global iron ore price increasing from USD40/DMT to USD60/DMT. This was seen to be very significant at the time as the price almost doubled once again. The price increased by approximately 300% over a period of five years (2004-2008).
- The global iron ore price increased at a steep rate from 2009-2011 to reach a peak price of approximately USD190/DMT late in 2010.
- 2012–2013 saw significant price volatility, with the global iron ore price falling from USD140/DMT to USD100/DMT and back up to USD160/DMT with an annual average of approximately USD140/DMT.

[1]Source data: BHP Billiton (2012), BHP Billiton (2014), BHP Billiton (2016), FMG (2012), FMG (2014), FMG (2016), Rio Tinto (2012), Rio Tinto (2014), Rio Tinto (2016), Vale (2011), Vale (2013), Vale(2015)

- Late 2013, a rapid decline occurred pushing the prices down to approximately USD40/DMT late 2015. Iron ore price traded in a range of between USD40/DMT and USD55/DMT for 2015.

The last decade has seen some significant gains in the iron ore price, as well as a significant correction during 2014/15. Most iron ore producers realised super profits during the period 2008-2014 and have been under severe pressure from 2015 by shareholders to produce the goods in a very challenging price environment. By researching public documents and data pertaining to the iron ore industry, the impact of supply and demand on global iron ore price will be determined.

1.2 Research motivation

Anglo American, that has interests in iron ore assets in South Africa and Brazil currently employs the author. Providing the context for the global iron ore business from a supply, demand and price perspective will assist with strategic decision-making inputs. The research will give insight into the potential outlook for the global iron ore industry over the medium to longer term. It will also provide guidance on the attractiveness of iron ore as part of a larger commodity portfolio.

1.3 Problem statement

The global iron ore price rushed to an all-time high of approximately USD190/DMT late in 2010 from below USD20/DMT in 2004 and collapsed to USD40/DMT in 2015, only 4 years later. The price drop could potentially be because of an over-supply situation, subdued demand or a combination of factors effecting the global iron ore market. The recent subdued iron ore prices, ranging between USD40/DMT and USD55/DMT for 2015 and between USD50/DMT and USD60/DMT for the first half of 2016 presented profitability challenges for a large number of iron ore producers. It is a major challenge positioning iron ore assets and companies when there is demand uncertainty with a potential impact on price.

It is in this context that this research aims to determine the key drivers effecting iron ore demand globally. It should be borne in mind that iron ore supply and demand affect price and hence profitability of key iron ore producers will be analysed as such.

1.4 Research objectives

It is evident that various factors were at play over the last decade resulting in the iron ore price fluctuating significantly. In understanding the impact of the supply and demand drivers on the price of iron ore, a literature review and detailed analysis are to be completed. To understand the impact of supply and demand on the iron ore price, various objectives will be met and are summarized as follows:

- Determine from literature review if the rise and fall in iron ore prices over the last decade (2005-2015) are typical of a commodity super cycle and if the recent collapse is a market re-adjustment or the end of the super cycle that started in 2005.
- Determine the key drivers for global iron ore demand and key economies.
- Analyse the global iron ore supply and demand over the period 2005 to 2015.
- Determine the impact of the global iron ore price collapse on the profitability and sustainability of the four major producers.
- Research the medium term outlook for the iron ore industry with consideration for intensity of use as a proxy for iron ore demand.

1.5 Scope of research

Supply and demand from the last decade (2005 - 2015) will be analysed to determine the key drivers behind the iron ore price boom and subsequent collapse. The scope is limited to the last decade as the global iron ore price was relatively flat for more than 20 years preceding 2005. From a global iron ore demand perspective, a detailed analysis will be conducted considering

China as the key economy. During 2015, China imported approximately 950 Mt out of a total of 1.5 Bt of seaborne iron ore (Worldsteel Association, 2010-2016).

The total global iron ore production for 2015 was in the order of 3.3 Bt. Approximately 60% of all seaborne iron ore was shipped to China, highlighting the significance of China in determination of the global iron ore price (Ng, 2016). India is seen to be the next emerging economy of significance and will be analysed on that basis. Emerging economies other than China and India will only be referred to if identified to be significant during the analysis. For supply, the total production will be considered and only the four major producers (BHP, RIO, Vale and FMG) will be analysed in detail as they account for approximately 40% of the 62% Fe normalized output.

The profitability of the four major producers will be analysed over the last five years (2010-2015) to highlight the impact of reduced prices on profitability. BHP, RIO, Vale and FMG are seen to be the lowest cost producers that underpin the global cost of production for iron ore. Literature in the public domain was researched to inform the medium term outlook for the iron ore industry. The intensity of use hypothesis were used as a proxy for steel consumption to inform future demand.

1.6 Methodology

The research largely followed a quantitative methodology. It covered the analysis of the iron ore business by evaluating key drivers of iron ore demand, the supply and demand balance and the impact on price. The method applied consisted of gathering data from secondary sources and a detailed quantitative analysis of population growth, GDP, GDP/Capita, stage of economic development, steel consumption, demand for iron ore, and intensity of use.

1.6.1 Gathering of data from secondary sources

The thirty-year time series data with specific attention to a period from 2005 to 2015 was analysed to determine if the recent boom in commodity prices constitutes a cycle or super cycle. The supply and demand fundamentals were researched to determine the key drivers for iron ore demand and to analyse the relationship between supply, demand and price. This is critical in economics and understanding the behaviour from producers, as well as consumers, is very important from a price perspective.

In taking a forward looking view of the iron ore industry, the analysis focused on the global cost curve and the intensity of use hypothesis. Various analyst reports were researched to gain insight into the medium term outlook for the global iron ore industry as a whole. This provided insight into the economic development of China and India and the potential demand for iron ore going forward from these two global economies.

1.6.2 Quantitative analysis

The quantitative analysis focused on a detailed supply and demand analysis over the last decade (2005 - 2015). From a demand perspective, the analysis focused on identifying the key uses for iron ore, as well as the largest consumers of iron ore. China is the key emerging economy that drove the increased demand for iron ore over the last decade with India as a potential significant contributor in time. From a supply perspective, the total global production was analysed per economy and significant producer. A financial analysis of the four largest iron ore producers, namely BHP, RIO, Vale and FMG, was undertaken to determine the impact of the 2015 price collapse on profitability and medium term sustainability. The cost of production was also analysed in detail as it underpins the iron ore price.

1.7 Report layout

To address the problem statement, the research report focused on detailed analysis of the iron ore demand, supply, price and key major producers. The research report consists of six chapters summarized as follows;

- Chapter 1: Introduction

  The introduction shows the severe fluctuations in iron ore prices from a base of approximately USD20/DMT in 2004 to reach a peak price of

USD190/DMT in 2010 after which dropping off to USD40/DMT in 2015. The introduction outlines the motivation for the research, the problem statement, objectives, scope and methodology followed.

- Chapter 2: Literature review

  The literature review focused on cycles and super cycles to compare the rise and fall in iron ore prices over the last decade with a typical cycle and super cycle. Supply and demand fundamentals were researched to identify the drivers for price determination. The significance of cost curves were researched and the role they play in understanding and informing iron ore prices. Iron ore prices were researched to establish how iron ore prices are determined. The intensity of use hypothesis were applied as a proxy for the demand for iron ore. Research was conducted for the global economy and growth as it plays a significant role in the demand for iron ore. The significance of China as a key emerging economy, and India in time, to inspire the need to research their economies.

- Chapter 3: Supply and demand analyses (2005-2015)

  This chapter focused on the uses of steel and how that impacts the demand for iron ore. Due to the significance of recycling, some analyses were done to highlight the current and potential impact of steel recycling on the demand for iron ore. The key economies effecting the iron ore industry from a supply and demand perspective were identified. The demand for iron ore was derived from first principles considering apparent steel use. The supply of iron ore data was researched based on data from the USGS (USGS) and other sources. The supply and demand balance were derived to determine if the market is experiencing an over-supply or demand situation.

- Chapter 4: Profitability & sustainability (2010-2015) - Iron ore price and cost curve analysis

The four largest producers of iron ore namely BHP, RIO, Vale and FMG, are also the lowest cost producers in the industry. Analysing their cost base and financial position will provide guidance on the minimum iron ore price that could be sustained during periods of low demand. The annual statements for the four largest iron ore producing companies, namely BHP, RIO, Vale and FMG, were analysed. The focus of the analysis was on profitability, margins, cost, capital, debt and equity. Cost curves were analysed to form an understanding of the relation between supply, demand and price over the period in question.

- Chapter 5: Iron ore industry outlook with reference to analyst views and intensity of use (post 2015)

  Global GDP growth provides an indication of the demand for steel and indirectly iron ore over time. Intensity of use considers to some extent the stage of economic development and provides guidance on the demand outlook for steel. This inspires the demand for iron ore considering the impact of steel recycling. The chapter attempts to provide some insight into the medium term outlook for the iron ore industry from a demand, supply and price perspective.

- Chapter 6: Key drivers of iron ore demand and impact on price

  This chapter provides a summary of data and information provided in chapter 3 to 5 relating to iron ore demand. It provides insight into the impact of supply and demand on price.

- Chapter 7: Conclusions & recommendations

  The chapter provides a summary of the research report. It concludes all aspects discussed relating to supply, demand and how that impacts on price.

2 LITERATURE REVIEW

2.1 Chapter overview

The literature review provides an overview of the fundamental principles of supply, demand and the impact on price. Commodity price cycles and super cycles are summarised to provide guidance for the duration of a typical commodity price cycle. The chapter provides insight into the global economy as a key determinant for the demand for certain commodities. According to Erten and Ocampo (2012), the global economy growth is materially influenced by emerging economies, in particular China. Erten and Ocampo (2012) also concluded that China heavily effected the accelerated demand for growth commodities due to its unprecedented drive for urbanisation and industrialisation. Price determination is summarized to provide an overview of the price setting mechanisms. An overview of the application of cost curves is summarised as it underpins the price for a particular supply and demand.

2.2 Cycles and super cycles of commodity prices

Commodity prices are subject to price fluctuation that over time follow price cycle and super cycles. The definition of a cycle, as defined in the Oxford dictionary is: “A series of events that are regularly repeated in the same order”. According to Roberts (2009), the peak is at the end of an expansion phase and is followed by a trough. The duration of an expansion phase is measured between the trough and the peak and the duration of the contraction phase is measured between the peak and the trough. The duration of an entire cycle is measured between two peaks with a trough in the middle. Roberts (2009) agreed with previous studies that found that contractions are on average longer than expansions. Roberts (2009) found that there is sufficient evidence to conclude that the metal price cycles are not random events and there is some degree of regularity. He also found that there is no correlation between the duration and amplitude of the price change.

According to Cuddington and Jerrett (2008), super cycles are defined by the duration with the broad range of commodities being impacted. After analysis, Cuddington and Jerrett recognised the fact that there were three distinct super cycles ranging from 30 to 40 years each over the last 150 years and that the industry entered the fourth super cycle in 2005. Cuddington and Jerrett (2008) have a view that the non-oil super cycles follow world GDP, indicating that the super cycles are predominantly driven by demand.

In broad terms the four commodity super cycles were driven by the United States of America (USA)' rapid economic growth, then followed by the resurgence of Europe after World War II, the emergence of Japan and ultimately the China growth story. There are two reasons why these cycles are classified as super cycles. The first reason is that these are long cycles with a typical upswing of 10 to 35 years and a complete cycle of 20 to 70 years. The second reason is that it is broad based in as far as a wide range of commodities being effected (Cuddington & Jerrett, 2008). According to Erten and Ocampo (2012), four distinct super cycles are defined during 1865 and 2009. For every super cycle the duration ranged from 30 to 40 years with amplitudes of 20% to 40% higher or lower than the long-run trends. They also concluded that non-oil commodities follow world GDP, indicating that commodity prices are generally demand driven. The 2004 to 2008 commodity boom was primarily driven by emerging economies and in particular China. Super cycles differ from short term fluctuations in two ways. Firstly, super cycles tend to span over a much longer period with upswings typically 10 to 35 years long and a complete cycle duration of 20 to 70 years. Secondly, a super cycle will impact a broad range of commodities and is typically driven by industrialisation and urbanisation of a developing economy.

According to Heap (2005), the late 19th century through 20th century, economic growth in the USA resulted in sustained long term demand for commodities. That was followed by the post World War II reconstruction of Europe, resulting in another upswing. He attributes the current expansionary phase to the industrialisation of the Chinese economy.

For this particular research project, iron ore was the only commodity considered, although the recent commodity price collapse is not limited to iron ore but also a number of other commodities.

2.3 Supply and demand fundamentals

Supply and demand are fundamental in understanding economics in general with no exception to commodities. The law of demand states that the higher the price of a good, the less quantity will be required for that particular good. The law of supply states, the higher the price, the higher the quantity of goods to be sold. When supply and demand are equal, the economy is said to be in equilibrium. Disequilibrium is when there is excess demand or excess supply. Excess supply is when the price is too high and additional quantity is supplied up to the point where there is more than demanded. Excess demand is when there is not enough quantity being supplied to meet the demand. This normally occurs when the price is too low and this stimulates demand. There are either movements along or a shift in the supply and demand curves (Heakal, n.d.).

2.4 Iron ore price determination and trade

Prior to 2008, iron ore prices were negotiated and operated for a duration of 12 months and even longer periods during earlier times. The emergence of China as a major global steel producer and consumer driven economy triggered the emergence of the spot price market. At the time, the Japanese market preferred longer term negotiated contracts. Supply of iron ore was fairly evenly balanced around 2004/2005 and some Japanese steel mills had no choice but to agree to spot market prices to secure supply to their mills (Sukagawa, 2010).

From 2008, the IODEX iron ore fines 62% Fe ($/DMT) has been the benchmark assessment price for the trade of iron ore. The benchmark price is based on a standard specification for iron ore fines at 62% Fe, 2% Alumina and 4.5% Silica and is stated in USD/DMT. Since the annual contract price agreement for global iron ore moved towards a spot price market, IODEX became the primary market price mechanism and has been used ever since. Various price normalisation factors insofar as premiums and discounts are applied to determine the global iron ore price for lump, pellet feed and concentrate. Various other normalisation factors are applied insofar as discounts and premiums for iron content and contaminants. The assessment is published on a CFR basis, Qingdao North China basis. Most recently price assessments now include daily iron ore spot prices for 63.5% / 63% Fe, 58% low grade iron ore and 65% high grade iron ore. The daily price is determined by analysing daily bids and offers (S&P Global, 2016).

According to van Niekerk (2013), China is still the largest driver for seaborne iron ore demand and has grown significantly over the last decade. China consumed 70% or 745 Mtpa of the seaborne iron ore by 2012 from less than 100 Mtpa in 2002. The iron ore consumption grew by more than 700% over a period of 10 years. This is mainly as a result of the urbanisation of China and the infrastructure required to support urbanisation. This will need to continue on the same path to meet expectations from the Chinese population. Understanding the demand side is critical in forecasting the global iron ore price. According to Worldsteel Association (2010-2016), China imported approximately 950 Mt of the total 1.5 Bt of seaborne iron ore during 2015, highlighting the significance of the increase from the said 2012 levels.

2.5 Cost curves significance and application

According to Hume (2015), a cost curve is a graph that plots the production capacity and the cost for an entire industry. Cost curves are very important in mineral economics and are generally used for the following:

- Provides a quick snapshot of the industry;
- Investors overlay current prices and expected future prices to judge which of the producers are profitable and which are not; and
- It is used to estimate price support levels.

Generally speaking, at the 90th percentile the remainder of the production would be responsible for 10% of the market production and would be considered as marginal operations. When prices come under pressure, these producers will be exposed from a margin and profitability perspective. The challenge here is that prices can trade below the 90th percentile for long periods of time. This is dependent on the duration for which the marginal producers can continue to operate. A particular cost curve will not be relevant for long periods as it will change continuously due to the global economic environment. For example, a major input cost, such as fuel for large open pit mines which is generally applicable to most iron ore mines, will result in a significant reduction in cash cost when oil prices are subdued as was the case during 2015. The ranking of various producers will in all likelihood remain similar with the overall cost base changing when global cost inputs changes (Hume, 2015).

Figure 2.1 provides a visualization from Mckinsey and Company (2009) of what an industry cost curve looks like and what information can be sourced from it. The X axis is essentially the available industry capacity from left to right and in this example from supplier A to supplier G. The X axis reads accumulatively. So in this case, the total available industry capacity is 24. The Y axis is the unit cost of production and normally excludes certain capital items. One can then see what the unit cost of production is for a particular supplier by reading of this axis. For example, supplier A can produce 4 units at $4. The market price as indicated in Figure 2.1 is the point where the supply and demand are in exualibrium and for this example 16 units are required at a price of $13. If the demand increase to 14 units, the price would increase to $14. This essentially demonstrates that the more units required, the higher the cost as it would accommodate higher cost units. There is also an indication of the market demand and the excess demand. The producers operating at a loss and essentially being responsible for the excess capacity, will attempt to reduce cost to fall within the market price. Equally the suppliers within the market price bracket will attempt to reduce cost to maximize windfall. As mentioned by Hume (2015), a cost curve presents a view at a specific point in time and is continuously changing. According to Mckinsey and Company (2009), there are various complexities with cost curves and interpretation. Mckinsey and Company (2009) state that it helps companies to predict the impact of capacity, changes in demand and input cost has on prices.

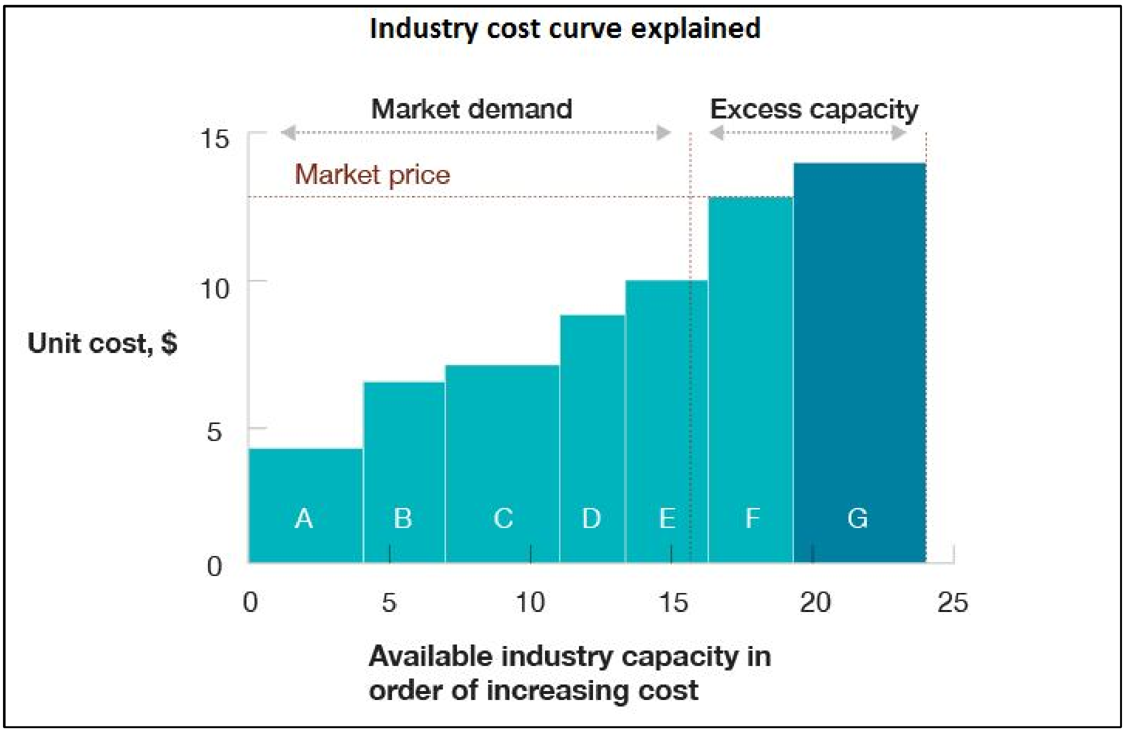

Figure 2.1: Industry cost curve explained (Mckinsey and Company, 2009)

According to Tholana, Musingwini and Njowa (2013), mining companies are predominantly price takers and hence the cash cost position in relation to the competition is very important. It is an indicator of the competitiveness and future sustainability of producers. The lowest cost producer will survive throughout the cycle whilst high cost producers will face very challenging times during periods of lower prices. The lower cost producers on the cost curve are typically large scale operations due to reduced fixed overheads per tonne produced and shared infrastructure. Producers with high-grade resources are also generally low cost due to limited processing requirements. The cash cost could be derived from the company's financial statements. The total cost, including depreciation and amortization, is very important but is more difficult to source and apportion to specific operations without using company-privileged information.

According to McConnon (2016), the cash cost position is critical to the long-term sustainability of any business given the cyclical nature of the business. In taking a forward-looking view of the global iron ore industry, the cost curve is critical to provide a sense of competitiveness and sustainability. Approximately 50% of all current iron ore tonnage is produced at a loss, with prices of approximately USD 50/DMT. The majority of these producers are located in China. This is not sustainable, the supply will correct itself over time as Chinese and other non-profitable operations close down. In cases where mines are government subsidised, it may take significantly longer for supply to be removed from the market. Producers operating at a loss will have no option but to undergo large cost reduction exercises, suspend operations until the price recovers or closing of operations.

According to Collins (2013), the very important demand line is not shown on the cost curve, as it will continuously change with price. Cost curve analysis will provide guidance for current demand by overlaying the current price and reading off the tonnage produced at or below the said price. By making use of the cost curve position provides a number of analytical tools. It provides guidance for price if demand reduces. It will also provide guidance for profitability, risk and competitiveness for various producers. The other very important aspect of a cost curve is that it only provides a view at a specific point in time due to continuous change in price and cost. It does, however, provide guidance and a framework for analysing various scenarios.

The impact of price on operating profit margins of financial metrics is a key factor for business continuity. Considering the profit margins for the low cost producers and the impact on the overall business, financial performance will provide guidance for price support levels. As discussed previously, the four largest and lowest cost producers are BHP, RIO, Vale and FMG.

2.6 Financial indicators

Numerous financial indicators and measures can be applied when comparing various companies from a profitability perspective. Indicators such as earnings before interest, tax, depreciation and amortization (EBITDA), EBITDA margin, and debt to equity ratio are good examples. Although many more indicators exist, the ones listed were applied to analyse the sustainability risk of the four major producers at subdued prices. According to Investopedia (2014), EBITDA grew in popularity due to the fact that it can be used to compare various companies on a consistent basis. It is very popular in highly leveraged companies in capital-intensive industries. For that specific reason, it is a good indicator for mining companies as such. Taxes are excluded because it can vary significantly between various operations and companies. Interest is excluded because it depends heavily on the financing model. It also removes the subjectivity around the application of amortization and depreciation. It is however, critical to mention that it is not a complete measure and has shortcomings, such as not including tax that will make a company appear cheaper than it is.

According to Klonsky (2010), The EBITDA equation is a simple one and is essentially revenue minus expenses. It excludes interest and tax, as well as depreciation and amortization. It basically provides an overview of the company's profitability and ability to pay what it owes. Although it is acknowledged that EBITDA is not the only profitability measure available, it does provide a good indication of a company's profitability for a particular period.

According to Uzialko (2017), EBITDA provides for a standard measure of profitability. The EBITDA measure gained popularity in the 1980s. It provides analysts with a measure to compare the profitability of various companies. It also assists with longer term projections on profitability, as well as the ability to pay off debt. A big shortcoming with the EBITDA measure is that it does not take the company's working capital into consideration. For example if a wealthy company has profitability issues, it may be less concerning than when a cash poor company has profitability challenges. There is a risk that EBITDA may provide a false sense of profitability. EBITDA margin is another variation of a profitability measure and takes the revenue into account. The calculation is EBITDA divided by total revenue.

According to Investopedia (2016), debt to equity ratios are used to measure a company's leverage. In essence, it is the amount of debt used to finance the company in relation to the amount of value representing the shareholders equity. Debt provides access to funds to expand companies and maximise earnings. The debt to equity ratio effects the cost of finance based on risk. It is very hard to determine the appropriate debt to equity ratio, as it is dependent on the global investment climate, and may in some cases be linked to a specific industry. From a pure risk perspective, a ratio of 0.4 and below is viewed to be reasonable since the interest on the loans must be paid regardless of whether a business is making money or not. Companies unable to service their own debt may be forced to sell assets or declare bankruptcy. Too much debt may result in cash flow drying up. For debt to equity ratio's higher that 0.6, it may be a challenge to borrow more money since business may be viewed to be over leveraged. Large businesses undergoing significant expansions may have higher debt to equity ratios, especially if they are capital intensive by nature. In summary, a ratio of between 0.3 and 0.6 is viewed to be reasonable with 0.4 being the average norm. During times of high commodity prices, when the objective would be to maximise profits by expanding the business, a high ratio would be beneficial over the medium term. When commodity prices are subdued, lower ratios are preferred from a risk point of view.

According to Gallo (2015), the debt to equity ratio provides an indication of the amount of debt used to run the company. Optimal debt to equity ratios are dependent on the type of industry. High debt to equity ratio is an indication that there may be a risk to repayment of debt. Low debt to equity ratios might expose the company as a take-over target. On that basis optimal debt to equity ratios are seen to be very important in maximising profits. Debt is generally cheaper than equity. So using sufficient debt support gearing to maximise profits, is seen to be an optimal business model.

According to Kennon (2016), long-term debt is money that is expected to be paid over longer than the next twelve months. Debt to be settled during the next twelve months is classified as current liabilities. Long-term debt is mostly used to fund business expansions and growth. The debt to equity ratio is an indication of how much debt a particular company has compared to its net worth. Debt to equity ratios will be viewed as high or low considering the overall economic environment and society's general appetite for debt and risk.

Generally speaking, companies with debt to equity ratios exceeding 0.4 to 0.5 may be exposed to liquidity issues. The economic cycle will provide guidance for a company's potential ability to repay debt and long-term loans. This should also be used to provide guidance for debt to equity ratios for business.

According to Investopedia (2016), operating cost is the expenses associated with the running of the business on a day-to-day basis. It generally excludes capital items and will typically include various expenses. Operating cost typically consist of fixed, variable and semi-variable expenses. Fixed cost is typically the cost portion targeted from an economy of scale perspective. These are costs borne by the business not related to the number of units produced. The smaller the output, the higher the unit cost and vice versa. Fix cost does, however, display step changes when the system capacity is reached. Variable costs are cost, which will only be incurred when units are produced. This is the cost component that does not change from a unit cost basis because of scale. A semi-variable cost would typically be a cost such as overtime. The assumption is that it often consists of a fixed and variable component and is viewed as semi-variable.

According to Lauren (n.d.), operational costs are routine costs incurred to run the business. It is essentially a combination of fixed and variable cost. Fixed cost remains constant from one month to the next and an example of this would be rent. Variable cost on the other hand would vary from month to month and an example would be utilities based predominantly on consumption. Examples of operating costs include, but is not limited to production costs, inventory, salaries and benefits and advertising and marketing.

After defining only but a few of the key financial analysis tools considered in this research report, one needs to have a good understanding of the demand for a particular commodity. The method of intensity of use is considered as an additional tool to provide high level guidance on the demand for key commodities.

2.7 Intensity of use as an indication of future demand

According to Soile (2013), intensity of use is perhaps the most widely used method to connect the quantity of raw material required to produce a particular product with the output of an economy in GDP per capita. That being said, various other factors should be considered when considering the consumption of a particular material than only the GPD per capita of a particular economy. The composition of materials in producing a product is one of the major shortcomings in the intensity of use hypothesis. For a developing economy, the transformation of an economy from agriculture to manufacturing will significantly increase the need for certain materials. With urbanisation and industrialisation of an economy, large infrastructure projects will produce roads, buildings, houses and other related infrastructure. This stage of economic development will change over time. The urbanization and industrialization phase will be followed by a shift to a services focused economy and will require different raw materials. Based on the changed stage of economic development, the consumption patterns for materials will change for the said economy. The demand for construction materials will reduce and other materials, such as platinum, will increase. Changes in regulation due to social pressure, as well as changes in technology, can significantly effect the type of raw materials and quantities required.

The notion of intensity of use is that more metal will be consumed per capita during the industrialization phase and less when the economy transitions into a services economy (Soile, 2013). In understanding the outlook for demand of certain metals, one must understand intensity of use and very important the stage of economic development. The stage of economic development will be a guide for demand for certain metals and can be compared to developed economies.

Soile (2013) analysed the intensity of use hypothesis for copper consumption in certain Asian economies and concluded the following;

- Linking intensity of use to the specific income per capita is too restrictive as it ignores some country specifics.

- Intensity of use for metals and in particular copper is higher for developing economies than services economies.
- Services economies have a very low intensity of use for metals.

According to Tilton and Guzman (2016), various changes that are unlikely to correspond with the income per capita, such as technology, will result in the intensity of use curve shifting. Because of this, the intensity of use technique poses some shortcomings. During the 1970s and 1980s various organisations and analysts used the intensity of use hypothesis as a demand forecasting tool. The intensity of use hypothesis can still provide useful insight into the nature of the demand for a specific commodity. Nowadays, a more detailed demand analysis is conducted by identifying the key end users and making use of various demand forecasting tools.

According to Malenbaum (1978), the world was alerted to the finite nature of non-renewable mineral resources during the years leading up to 1978. He stated that mineral resources were a key input for economic development and industrial throughput. The specific objectives of the study were to firstly provide a realistic forecast for the demand for identified materials including steel, iron ore, nickel, manganese, ferroalloys, chrome ore, cobalt, tungsten, refined copper and secondly to contribute to the methodology of intensity of use. The focus of the study was on the demand side of the said materials. The study attempted to provide global estimates for the demand for industrial raw materials in 1985 and 2000. He found that the global growth rates for raw materials were higher than the economic growth, measured in GDP, over the period 1951 to 1975. The highest growth rates in consumption were from poor countries over the said period. The intensity of use for raw materials were driven by GDP relative to the population size. He found that the forces responsible for the declining intensity of use were a shift in the types of final goods and services demanded, technological developments influencing the efficiency and utilization of raw materials and lastly the impact of substitution of certain raw materials. The declining rates for intensity of use mostly manifested in rich countries. The movement of intensity of use and rate of change will differ per region and material type.

As part of this study China and India, as two key developing economies, are compared to developed economies such as the USA, Japan and/or other European economies in providing guidance for the potential demand for iron ore. The intensity of use hypothesis will only be used as a guide to provide insight into the nature for demand of iron ore due to the limitations discussed and will be supplemented with various analysis views and forecasts.

2.8 Global economy and growth

According to Cuddington and Jerrett (2008), the non-oil super cycles follow world GDP, indicating that the super cycles are predominantly driven by demand. According to the Oxford dictionary, the definition for GDP is: “The total value of goods produced and services provided in a country during one year.” Figure 2.2 provides a summary of the top twenty countries by GDP over the period 1995 to 2015 in nominal terms. The top twenty countries by GDP account for more than 80% of the world GDP. China grew the most by far over the period 1995 to 2015. The significant increase in GDP growth rate occurred from around 2001/2002. The USA grew at a reasonably stable rate over the same period, with Japan remaining relatively flat. It is, however, evident that China, as indicated by the red arrow, had the biggest impact on world GDP growth over the said period.

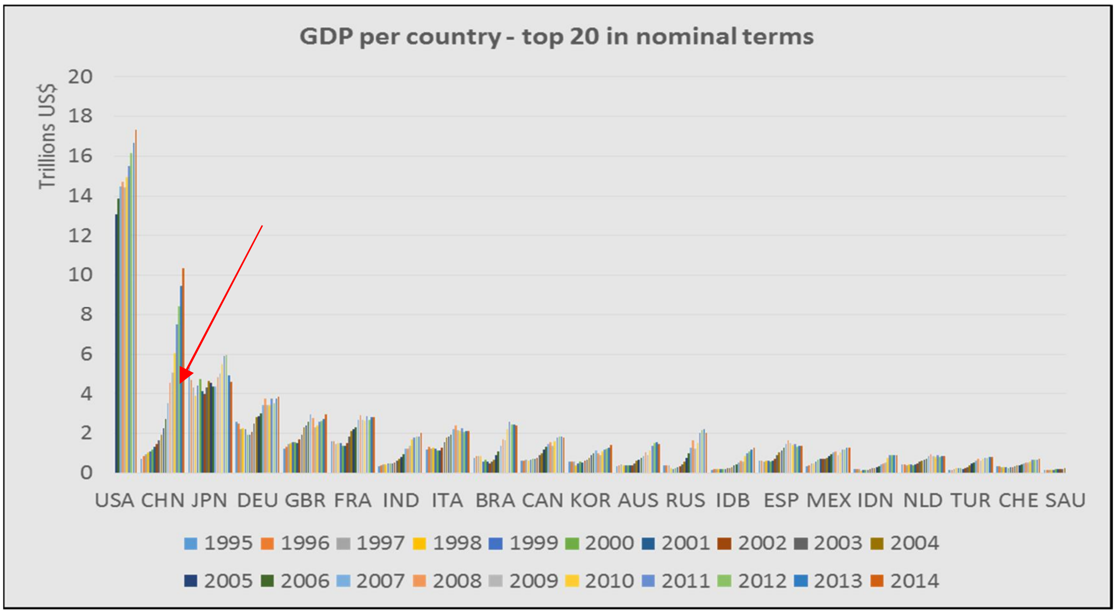

Figure 2.2: GDP per country (The World Bank, 2016)

Figure 2.3 provides a summary of the annual GDP growth for the world as a whole and identified key emerging economies namely China and India. The data shown represents real or constant terms, hence takes the effect of inflation into consideration. The increase in GDP growth rate from 2001/2002 is consistent with that of Figure 2.2.

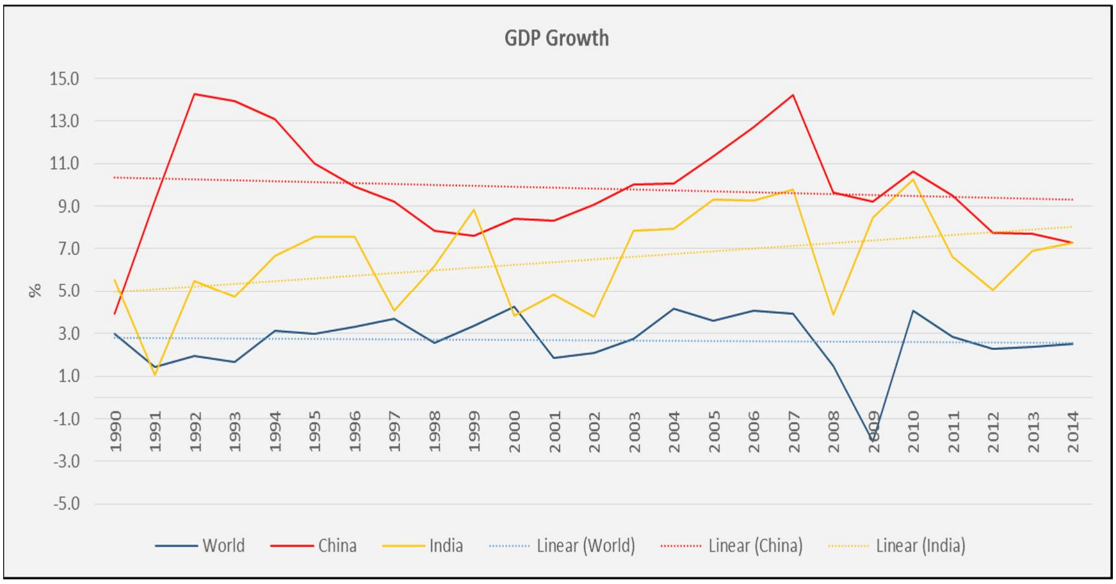

Figure 2.3: GDP growth per annum (The World Bank, 2016)

From Figure 2.3, the world average GDP growth per annum from 1990 and 2014 was slightly below 3%. The period from 2008 and 2009 was particularly challenging for world GDP growth due to the occurrence of the global financial crisis (GFC). During the four years leading up to 2008/2009, the world GDP growth was reasonably stable and was averaging around 4% per annum. The world GDP growth for the last four years was averaging approximately 3%. According to the International Monetary Fund (2016), global economic activity remained subdued due to a decline in GDP from emerging markets and developing economies. Developing economies account for approximately 70% of global growth highlighting the significance of these economies. There is a continuation of improvement in growth for developed economies. According to the International Monetary Fund (2016), the major risk to global economic growth is the Chinese slowdown and the transition and re-balancing of the economy from an industrialisation to services economy, lower commodity prices and the gradual tightening of monetary policy in the USA. It is important to understand which countries contribute the most to world GDP.

Figure 2.4 shows the top ten countries by GDP in nominal terms, which account for approximately 67% of the world GDP (IMF, 2016). The USA is currently the largest global economy and accounts for approximately 23% of the world GDP. With China being the second largest economy, it accounts for approximately 18% of the world GDP. The two countries collectively contributes approximately 42% of the world GDP. This emphasizes the significance of the USA as the largest developed economy and China as the largest emerging market and developing economy. The third largest contributor is Japan at approximately 4% of the world GDP and albeit significant, not nearly as big as the USA and China. Germany, UK and France contribute approximately 3% to 4% each and Italy, Brazil and Canada approximately 2% each. The three most significant developing economies are China, India and Brazil, with China being the most significant by a long way.

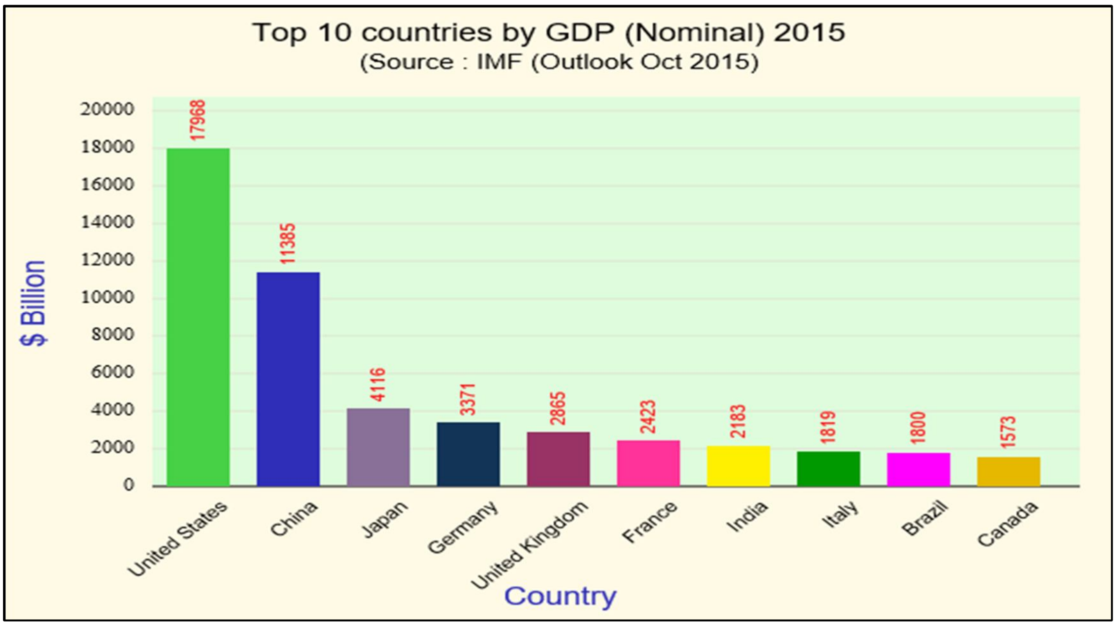

Figure 2.4: Top 10 countries by GDP (Statistics times, 2016; International Monetary Fund, 2016)

The demand for commodities is primarily driven by emerging markets and developing economies due to industrialisation and urbanisation. With significant infrastructure projects, the demand for commodities will increase rapidly and will be associated with economic growth. Although developed markets and economies will continue to support the demand for commodities, the growth in demand will be driven by developing economies. As per Figure 2.4, the GDP per annum for China and India is the largest for developing economies out of the top 10 countries per GDP. Brazil's GDP contracted by approximately 3% in 2015 (The World Bank, 2016).

According to the World Bank (2016), the GDP growth in China is currently approximately 6.5%, which is significantly lower than the annual GDP growth of above 9% during the period 2002 to 2011. This is signalling a slowdown in growth, however, at 6.5% the growth is still seen to be significant. As for India, the annual GDP growth rate is approximately 7.5%. As for the largest developed economies, the GDP growth rate is approximately 2.5% for the USA and approximately 0.6% for Japan, once again highlighting the significance of China as a major global economy. GDP on its own is not a good measure for wealth, poverty alleviation and phase of economic development due to varying population distributions. A more accurate measure is GDP/capita and is applied in the intensity of use theory.

The population and population growth is a very important factor since the GDP/capita growth rate should exceed the population growth rate to improve the standard of living. Figure 2.5 indicates the changes in global population over the last 25 years and summarises changes in the population of China and India over the same period (The World Bank, 2016).

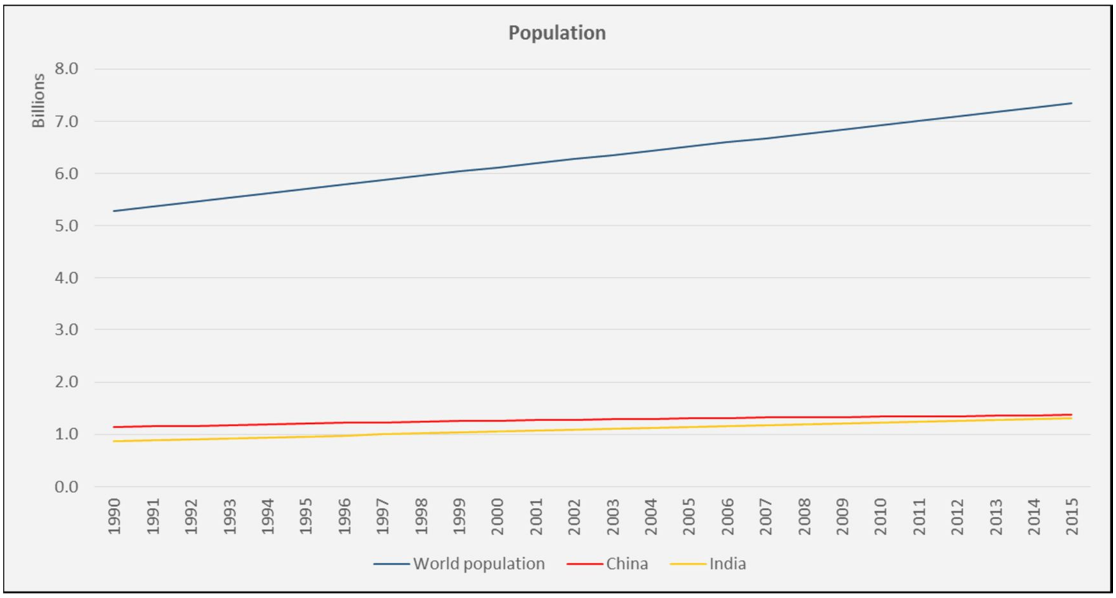

Figure 2.5: World population with China and India (The World Bank, 2016)

The global population grew from just over 5 billion in 1990 to approximately 7.3 billion in 2015 at an average growth rate of approximately 1.3% per annum. Over the same period, the world GDP grew at an average rate of approximately 2.7%. The rate of GDP growth was significantly higher than the rate of population growth. Collectively, the population for China and India is approximately 35% of the world population. The Chinese population is growing at a modest annual average rate of approximately 0.5% and India at approximately 1.2% (The World Bank, 2016). The sheer size of the Chinese and Indian population is an indication that significant economic growth will be required to improve the GDP per capita to the point where it is meaningful. Figure 2.6 is a summary of the top ten most populous countries in the world.

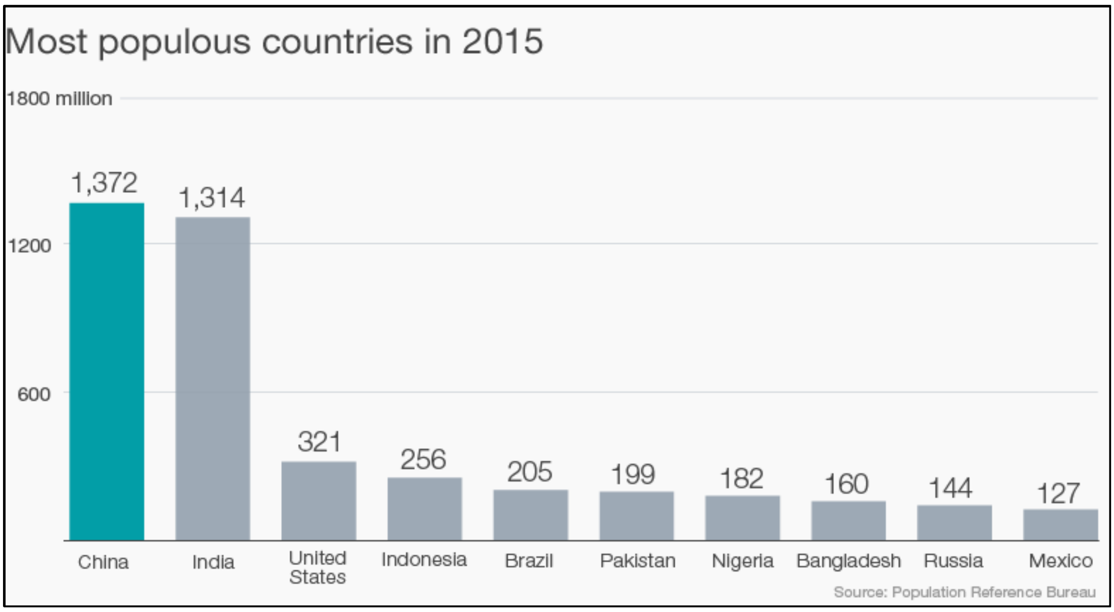

Figure 2.6: Most populated countries in the world (Kottasova, 2015)

Figure 2.6 indicates the significance of the Chinese and Indian population from a global perspective. Figure 2.7 summarizes the world GDP per capita, as well as the two largest developed economies, namely the USA and Japan, as well as the two largest developing economies, namely China and India (The World Bank, 2016).

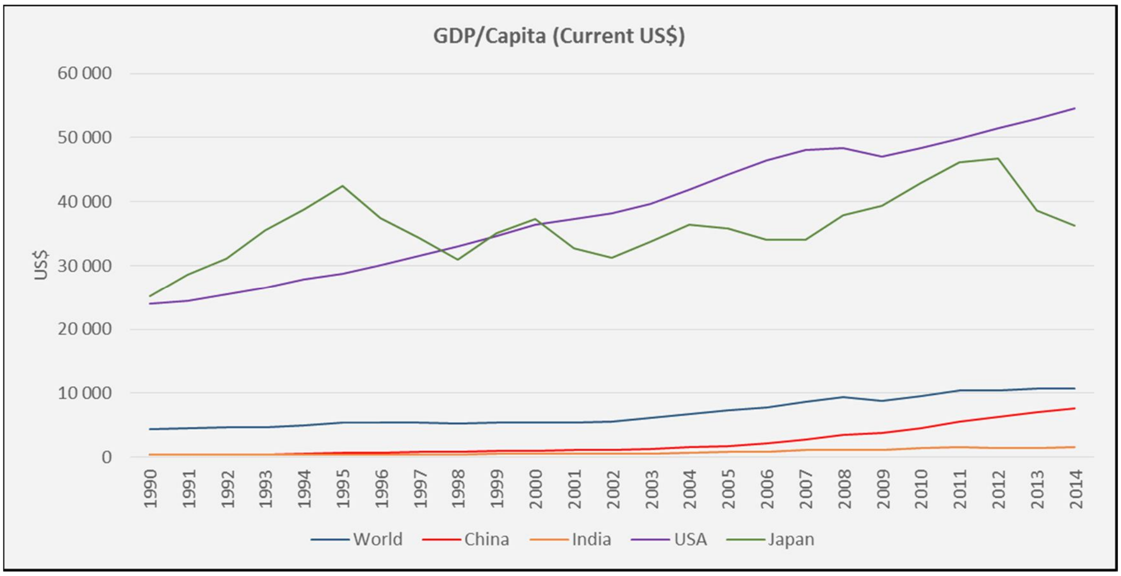

Figure 2.7: GDP/Capita in current US$ (The World Bank, 2016)

The world GDP per capita indicates a relatively slow annual growth rate at approximately 2.2% over the period 1990 to 2002. For the period 2003 to 2011, the annual GDP per capita growth rate was very high at approximately 7.5%. Post 2011, the annual GDP per capita growth rate was significantly lower at approximately 1.2%. For the period 2003 to 2011, one can observe significant world GDP per capita growth primarily due to the growth rate of China at approximately 19.4% and India at approximately 13.6%. The USA and Japan also contributed albeit much less at approximately 3% and 4.6% respectively. It is evident from the graph how significant and consistent the USA growth rate per capita was over the last 25 years (The World Bank, 2016).

Now that the significance of China has been defined as the single biggest developing economy driving global GDP with India being the second largest, a summary of both economies and growth potential are presented.

2.9 China's economy and growth

According to the World Bank (2016), China has shifted from a centrally planned economy to a marked based economy since market reforms in 1978. China experienced significant economic growth and social development. The GDP growth rate averaged 10% per year and is the highest in history for a major economy. China's large population at 1.3 billion people is a contributing factor in the significance of China as a key global economy. The rapid economic growth resulted in significant challenges, such as high inequality and environmental challenges and sustainability. China is still seen to be an emerging economy as the GDP per capita is still very small compared to developed economies. Japan, for example, had a GDP per capital of US$36,200 for 2014 with China only at US$7,600 for the same year. The definition for an emerging economy is not entirely based on the GDP per capita, but is also dependent on a range of other economic measures such as education.

According to the World Bank (2016), the global population estimate is 7.3 billion people. Based on these numbers, China accounts for nearly 18% of the global population. China's population is only growing at a marginal rate of approximately 0.5% per annum though, mainly because of the one child policy. In addition to the largest population, China is the second largest economy after the USA. China lifted more than 800 million people out of poverty because of the sustained economic growth.

According to The Economist (2016), China will face serious headwinds to continue growing at historical rates and significant policy reforms will be required to support sustained growth. China's working-age population peaked in 2012. Investment slowed down and appears to have peaked out. Government, household and corporate debt were at 250% of GDP, and the inventory of unsold homes sits at record levels.

According to the World Bank (2016), China addresses some of the challenges in the 13thfive-year plan for the period 2016-2020. The annual growth target in the latest five-year plan is 6.5%. This is significantly lower than the 10% maintained historically, but still seen to be significant. The latest five-year plan will focus on reducing pollution, increasing energy efficiency, increasing access to education and healthcare to improve social imbalances. A re-balancing of the economy is being targeted and not growth for the sake of growth.

According to Lin from the World Post (2016), China will keep on growing. Lin is of the opinion that major infrastructure investments from the past mainly focused on connecting cities through highways, high-speed trains, airports & seaports. There is a serious need for infrastructure development within cities such as sewage systems and subways. There is also a serious need for investment into environmental protection. The urbanisation rate for developed economies generally exceeds 80%, with China currently only at 55%. Based on the relatively low percentage of the population living in cities, urbanisation will continue to increase and there is a need for urban infrastructure development such as houses, schools, hospitals, etc. There is also sufficient fiscal flexibility. Government debt is currently less than 60% of GDP; household savings is approximately 50% of GDP and China has $3.3 trillion of foreign exchange reserves, the largest in the world. Based on this analysis, there is sufficient financial flexibility to grow.

2.10 India’s economy and growth

According to the World Bank (2016), India has a population of 1.2 billion people. This is approximately 17% of the world population. China and India are very similar in terms of population size and when combined, these two major economies account for almost 35% of the word population. India’s large population of 1.2 billion people is a contributing factor in the significance of India as a key global economy. India’s population is growing at an annual rate of approximately 1.2%. Over the last 60 odd years since independence, India made significant progress on the agricultural front and is a net exporter of agricultural produce. India is currently the 7^{th} biggest economy in terms of nominal GDP.

According to the World Bank (2016), the current urbanised population in India is 33% of the total population. The urbanisation rate is approximately 0.4%, which translates to 5 million people moving to cities annually. Significant infrastructure development will be required to support the high rate of urbanisation. There is in particular a need for roads, trains, ports, airports, etc. Poverty in India also effects a large size of the population with more than 400 million people living in poverty. The GDP growth rate is approximately 7.5% per annum, which is significant. According to the IMF (2016), the expected growth rate for India is 7.5% for 2016 and 2017.

2.11 Chapter conclusion

According to Cuddington and Jerrett (2008), the commodity market entered the fourth super cycle in 2005 with the industrialisation and urbanisation of China as the primary driving source for demand for metals. The first commodity super cycle was due to the emergence of the USA, followed by the industrialisation of Europe after World War II. Japan then followed Europe, which resulted in the third commodity super cycle with China resulting in the fourth. Super cycles tend to occur over a period of 30 to 40 years with an upswing of 10 to 35 years. Considering the start of the said cycle in 2005 and viewing the peak during the latter part of 2010 as an outlier, one could argue that the end of the upswing was 2014, resulting in a duration of 10 years. This is consistent with the minimum upswing duration of 10 years. Correlation with a broad range of commodities is not in scope for this research report so will not be commented on. Although there has been a clear collapse in price, it is too early to define it as the end of the super cycle and could merely be a market correction, since the prices are still significantly higher than pre-2005.

Cuddington and Jerrett (2008) have a view that commodities follow world GDP and are demand driven. Erten and Ocampo (2012) also concluded that non-oil commodities follow world GDP and that the demand for commodities are predominately demand driven. According to data from the World Bank (2016), the large economies able to impact world GDP at present are limited to a handful namely the USA, China, Japan, India and Brazil.

From 2008, the IODEX iron ore index has been recognised as the benchmark assessment price for the trade of iron ore. The benchmark price is based on a standard specification for iron ore fines at 62% Fe, 2% Alumina and 4.5% Silica with various penalties and premiums applied to non-spec products (van Niekerk, 2013).

The cost at which the specific supply can be delivered, is summarised on an industry cost curve. According to Hume (2015), a cost curve is a graph that plots the production capacity and the cost for an entire industry. Prices are overlaid at a specific point in time to identify producers that will be profitable and producers that will come under pressure at that particular price. It is important to note that a cost curve continuously changes due to various factors and will not be valid over long periods of time.

Financial Indicators are important to assess the profitability of producers at specific commodity prices. For the research report, metrics such as EBITDA, debt to equity ratios and operating cost relating to profit margins are used. According to Katherine (2015), EBITDA provides for a standard measure of profitability. The calculation is revenue minus cost with the exclusion of interest, tax, depreciation and amortization. It provides an indication of a company's ability to repay debt. According to Gallo (2015), the debt to equity ratio provides an indication of the amount of debt used to run the company. The calculation is total debt divided by the company's equity. According to Kennon (2016), a ratio of more than 0.4 to 0.5 could potentially flag liquidity issues with the risk of being unable to service debt.

Demand determination is a key factor in understanding at what price supply can meet demand. According to Malenbaum (1978), the demand for materials increased at a higher rate when compared to the increase in GDP over the period 1951 to 1975. The increase in materials consumptions from poor countries were higher than that of rich countries over the said period. He found that economic development, measured in GDP, requires an increase in raw materials. He applied the intensity of use measures for demand projections. According to Soile (2013), intensity of use is a model that correlates the demand for a particular material or commodity to the stage of economic development stated in GDP per capita. According to Tilton and Guzman (2016), detailed demand models are being used to predict demand for a particular commodity.

Analysing major economies is critical in quantifying the increase in demand for certain commodities. The USA, as the largest developed economy, increased its GDP by US$4.9 trillion with China, as the largest emerging economy, increasing by US$8.6 trillion over the period 1995 to 2015. According to the World Bank (2016), the world GDP grew at an average annualised rate of just under 3% per annum in real terms over the last 25 years (1990-2015). Developing economies account for approximately 70% of global growth highlighting the significance of these economies, in particular China and India (International Monetary Fund, 2016). According to the World Bank (2016), China's GDP will grow at an annual rate of 6.5% over the next 5 years. This is significantly slower than the last 25 years, primarily due to a rebalancing of the economy with a clear focus on environmental, healthcare, education and social imbalances.

According to Lin (2016), Chinese government debt is currently less than 60% of GDP, household savings is approximately 50% of GDP and China has the largest foreign exchange reserve in the world estimated at $3.3 trillion. Based on this analysis, there is sufficient financial flexibility to grow.

According to the World Bank (2016), India was the second largest emerging economy in 2015 after China. With urbanisation at 33% and an annual urbanisation rate of 0.4% for 2015, five million people are moving to cities annually. According to the IMF (2016), the forecasted annual GDP growth rate for India is significant at 7.5% for 2016 and 2017.

Understanding the supply and demand balance for iron ore is critical in determining the impact on the price of iron ore. Chapter 3 will provide an in depth analysis of the supply and demand for iron ore over the period 2005 to 2015.

3 SUPPLY AND DEMAND BALANCE (2005-2015)

3.1 Chapter overview

In understanding the global iron ore prices, one must have a broad understanding of supply and demand for iron ore. This chapter will identify the primary uses for iron ore to determine the key drivers for demand. Industrialisation and urbanisation of key developing economies play a significant role in the demand for key metals and ultimately commodities. A first principle approach will be followed to derive the iron ore demand based on steel consumption. An analysis will be completed to identify the key economies relating to the consumption and production of iron ore.

The four largest global iron ore producing companies contribute significantly to the total production and will be considered for the analysis. The four comprises of BHP, Vale, RIO and FMG. The scope is limited to ten years (2005-2015) and coincides with the period which saw a significant increase in global iron ore price during 2005, as well as the recent collapse in global iron ore price during 2014 (Admin, 2016).

3.2 Types of iron ore

Iron ore is most often found in the form of hematite and magnetite and according to Gindalbie Metals Ltd (2016), the current hematite versus magnetite production split is 50:50 on a global scale. Other types of iron ore such as goethite, siderite and limonite, are also common. Beneficiation requirements are based on mineral concentration and market requirements, typically consisting of dense media separation or jigging technology, post crushing and screening.

Table 3.1 provides a summary of the key differences between hematite and magnetite. The iron content for the pure mineral is higher for magnetite than hematite; however, the iron content for hematite is typically much higher than that of magnetite ores. Magnetite is also magnetic, where hematite is not. The colour for hematite is reddish-brown and for magnetite a dark grey-black.

Table 3.1: Comparison between hematite and magnetite (Shaw, 2017; Goeke, 2011)

	Hematite	**Magnetite**
Chemical formula	Fe_2O_3	Fe_3O_4
Iron content - pure mineral	70%	72.4%
Typical iron ore content	56%-64%	25%-40%
Magnetic characteristics	Non-magnetic	Magnetic
Colour	Red-brown	Dark grey-black

Hematite is named after the Greek word for blood, ("haima") because of its reddish colour and high iron content. Due to the high iron content, this type of ore is often only crushed and screened with no further beneficiation required before is sold to steel producers. This is also referred to as direct-shipping ore (DSO). DSO iron ore typically have an iron content of between 56% and 64% Fe. Hematite ore is common around the world. Itis found in abundance, and in particular parts of the world, such as Australia, Brazil and Asia. It is the primary ore type mined in Australia from the 1960s. Approximately 96% of the country's exports are high-grade hematite ore from the Western Australia territory. Magnetite ore has a higher iron content but is often found in lower concentrations. It is common for this type of iron ore to be beneficiated in order to concentrate the iron content before it can be used to produce steel. The product post processing is a high grade (+65%Fe) concentrate which is then further treated to produce pellets before using it to make steel. The most distinct property of magnetite ore is its inherent magnetic properties. Impurities are reduced through beneficiation and as a result, making it more attractive for steel producers thus classifying it as a premium product. Steel is used to manufacture railways, ships, cars, bridges, roads, trains, buildings and much more. Because of that, understanding the demand for steel is fundamental in determining the demand for iron ore (Iron Investing News, 2016).

3.3 Types of steel

There are four major steel classifications, namely: carbon steel, alloy steel, stainless steel and tool steel (Bell, 2016). Although many other classifications exist within the three major classifications, they are not seen to be material for this research report.

According to the (USGS, 2013), carbon steel production accounted for approximately 94% of total production with low alloy steel making up approximately 3.5% and stainless steel, which is defined as a high alloy steel, approximately 2.5%. This provides an indication of the importance of carbon steel since it is by far the largest contributor. Carbon steels vary from low to high carbon, with a carbon range of 0.3% to 1.5%. Carbon steel consist of iron, carbon, silica and manganese. The weighted average iron content for global steel production, based on iron content in carbon steel, low alloy steel and high alloy steel is estimated at approximately 97%.

3.4 Uses of steel and consumption per sector

According to the USGS (2016), approximately 98% of global iron ore production is used for steel manufacturing. On that basis, using steel as a proxy for iron ore from a supply and demand perspective is a reasonable assumption. It is, however, important to recognise that, although they are directly related, there will be other drivers impacting the price predominantly related to stock movement.

Figure 3.1 provides a summary of the 2013 global steel consumption per sector. The market is primarily driven by construction at 50% to 60% and secondary by machinery at 20-25%, collectively accounting for approximately 70% to 85% of the global market. Automotive consumption is much smaller at 6% to 7%, with appliances, ship building and others accounting for less than 7% (Mukherji, 2015).

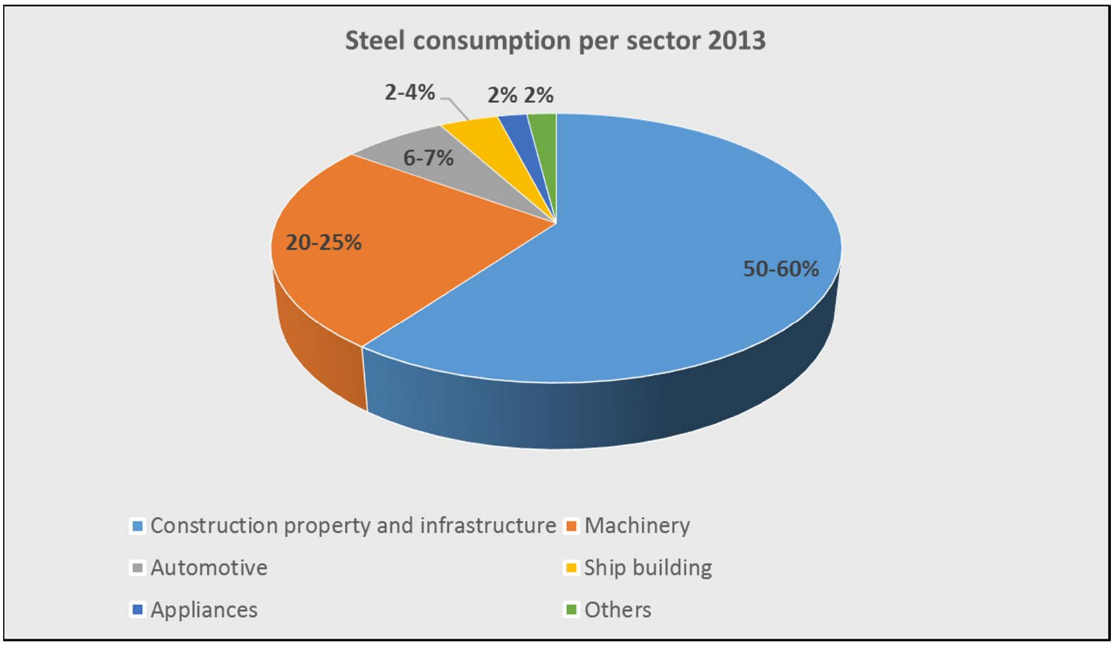

Figure 3.1: Global steel consumption per sector 2013 (Mukherji, 2015)

From Figure 3.1, the demand for steel is heavily impacted and primarily driven by construction signifying the dependence on emerging markets. Any material drive for urbanisation, resulting in the need to build large cities and related infrastructure, would have a significant impact on the demand for steel. In order to have an impact on the global consumption, a significant increase is required from a smaller population or lesser demand, but still material from a large population.

According to Elliot (2015), the consumption per sector will change depending on the stage of economic development. When an economic activity is primarily driven by agriculture, the requirement for steel will be insignificant. When there is a transition to a manufacturing economy resulting in large industrialisation, the consumption of steel increases significantly. When the stage of economic development transitions towards a services economy, the consumption of steel will slow down and will eventually reduce.

Figure 3.2 shows the typical steel consumption for developed economies. The highest steel consumption relates to the construction sector at 36%, followed by the automotive sector at 22% and steel products at 20%.

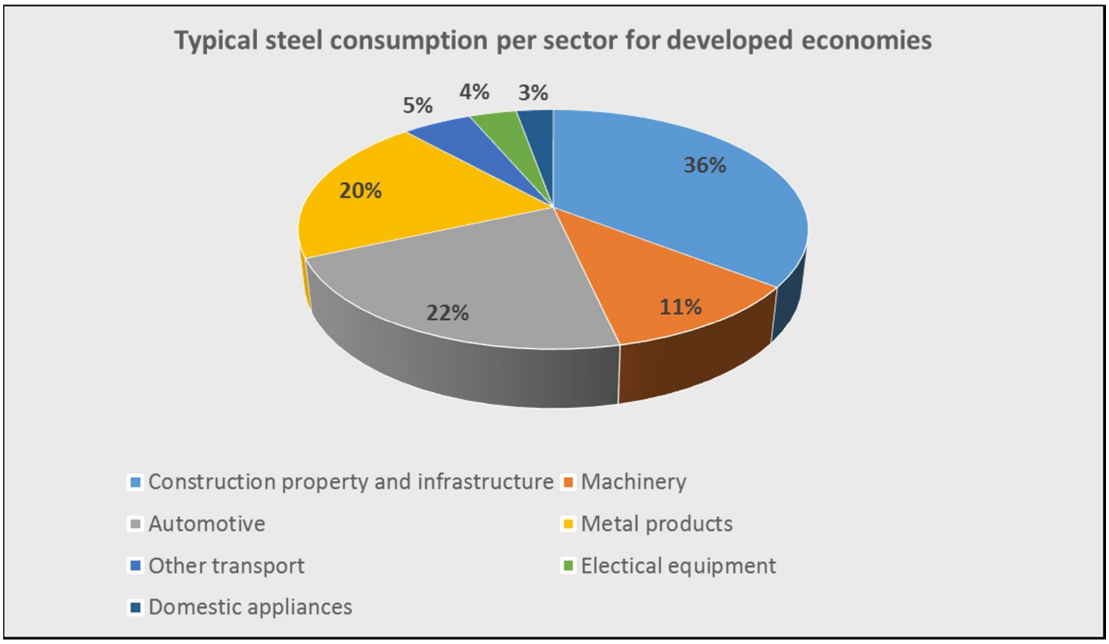

Figure 3.2: Typical steel consumption per sector for developed economies (Worldsteel Association, 2010-2016)

3.5 Global steel consumption (demand)

Global steel demand is critical in establishing the consumption patterns to determine the demand for iron ore. Apparent consumption of steel is defined as the "statistically-derived figure for national or regional steel consumption during a given period. It is based on the sum of reported mill shipments of finished steel plus steel imports into the country/region, minus steel exports." (S&P Global, 2017). Apparent consumption is well published and data is relatively easy to obtain. Real consumption takes into consideration changes in stock levels and obtaining a reliable source is a challenge. Considering the long period (ten years) in question, the difference between the two will be immaterial, hence the decision to make use of apparent steel consumption. Figure 3.3 provides an overview of the global apparent steel consumption over the period from 2005 to 2015.

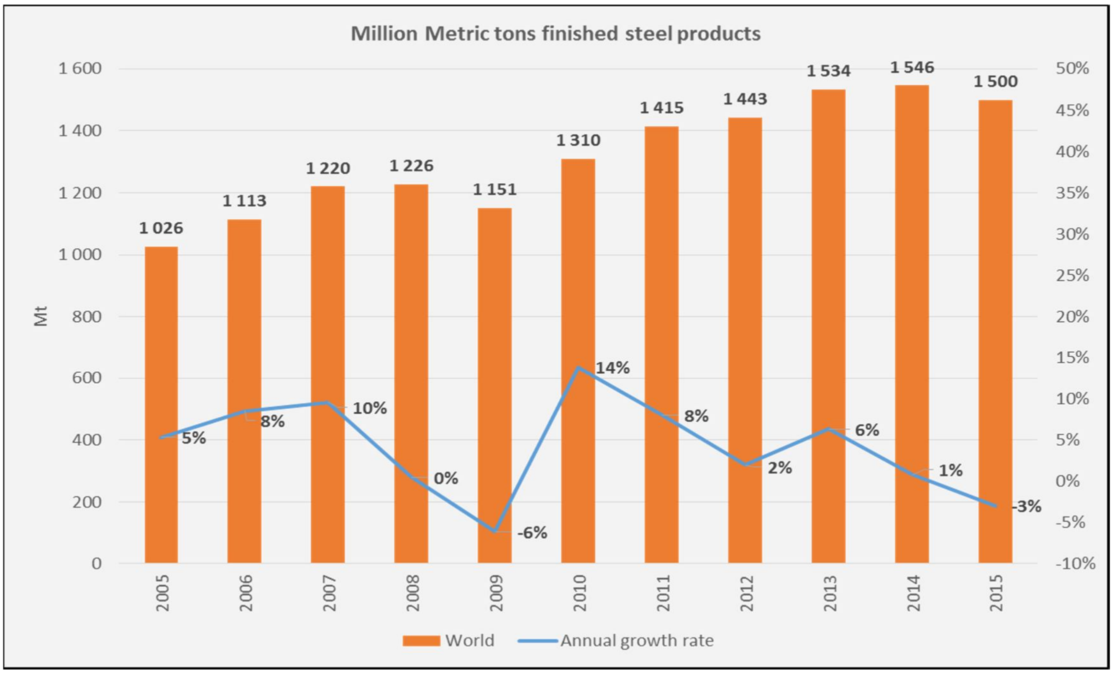

Figure 3.3: Apparent world steel consumption (MESTEEL, 2016)

The global apparent steel consumption was approximately 1Bt in 2005 and grew at a rate of approximately 9% year on year from 2005 to 2007 with two years of subsequent contraction in 2008 and 2009 because of the GFC. This was then in turn followed by reasonable global growth in apparent steel consumption from 2010 to 2013 at an annualized average rate of approximately 7.5%. For 2014, the growth was a modest 0.8%, with 2015 experiencing a contraction of 3%, seeing the first decline in global apparent steel consumption since the GFC of 2008. Over the last decade, the global apparent steel consumption grew by 46% or 3.9% annually (MESTEEL, 2016). Since the primary use of iron ore is for steel production, the consumption of steel can be viewed as a proxy for iron ore consumption and ultimately demand.

Figure 3.4 provides a summary of the top 10 countries, excluding China, by apparent consumption of steel over the period 2005 to 2015. The top 10 countries account for almost 75% and represents the global steel market reasonably well. China is by far the largest steel consumer and will be discussed separately due to its dominant market position. The USA is the second largest consumer at approximately 100 Mt per annum or 6% for 2015.

The USA has been consuming 80 Mt to 120 Mt of steel for the last decade. There was no clear growth in consumption levels over the last decade. The 2008 GFC impacted the consumption of steel significantly, since 2009 was almost half that of 2007 pre-GFC. The third, fourth and fifth places are all taken up by Asian economies, namely: India, Japan, and South Korea, in that order. The GFC appear to have had very little impact on the consumption in India as it grew steadily over the GFC period. India doubled consumption over the last decade and essentially grew at 7% per annum. It would appear that the GFC had an impact on the other eight large consuming economies.

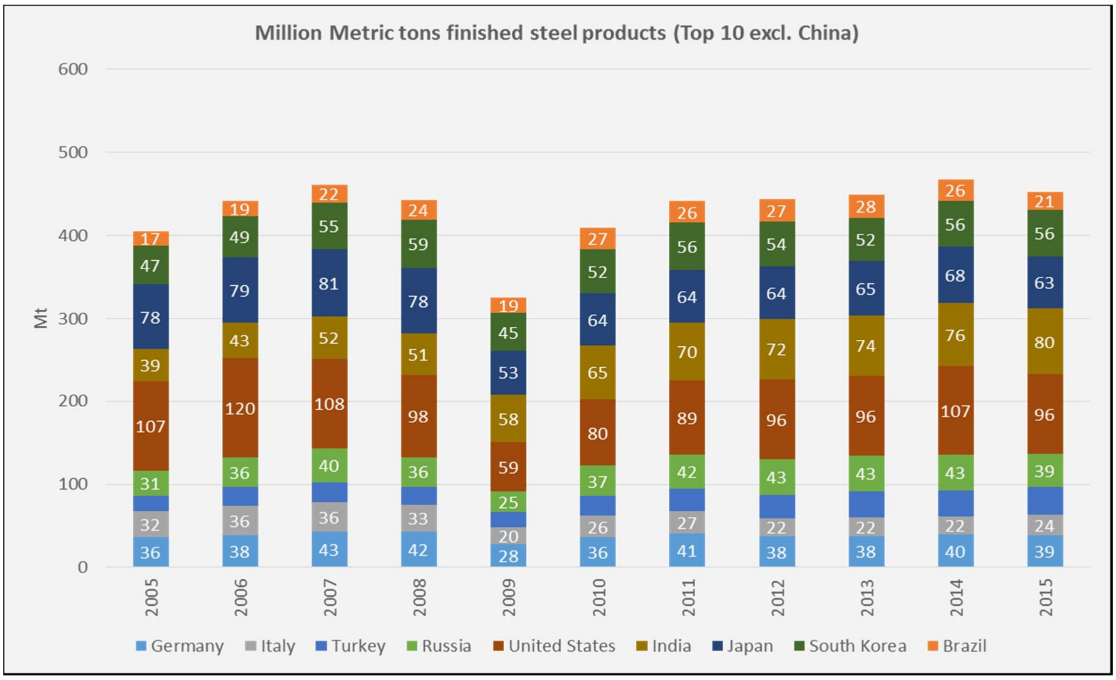

Figure 3.4: Apparent steel consumption, top 10 countries excluding China (MESTEEL, 2016)

There is no material growth evident in annual consumption from Japan, South Korea, Russia, Italy, Germany or Brazil over the last 5 years post the GFC. Only the USA and India realised some growth in steel consumption over the last 5 years; however, it is not seen to be significant. It is evident from Figure 3.4 that none of these countries had a significant impact on the global consumption growth rate of approximately 3.9% annually from just over 1Bt in 2005 to 1.5Bt in 2015 (MESTEEL, 2016).

As discussed in Chapter 2, Cuddington and Jerrett (2008) have a view that demand follows global GDP. Figure 3.5 provides a relative comparison between world GDP and apparent steel consumption over a prolonged period of twenty-five years. It is evident that there is close correlation. It confirms the view from Cuddington and Jerret (2008) that demand follows world GDP in non-oil super cycles.

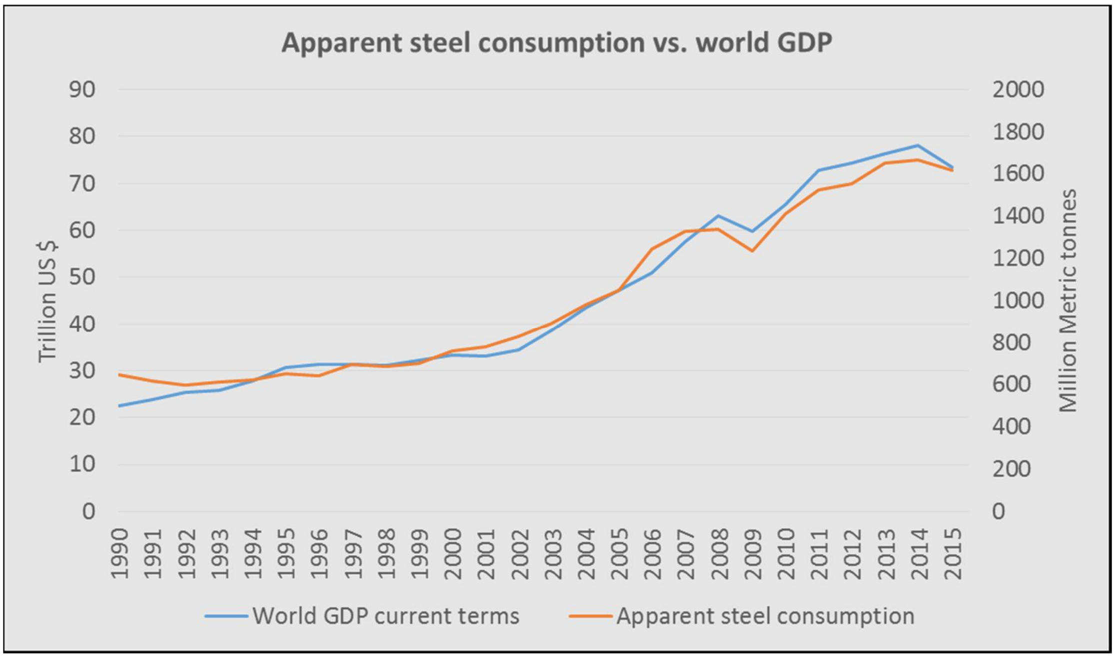

Figure 3.5: Apparent steel consumption vs. world GDP (MESTEEL, 2016; The World Bank, 2016)

Figure 3.6 provides an overview of the apparent consumption of steel for China over the period 2005 to 2015. During 2005, the steel consumption was just over 300 Mt and increased rapidly to approximately 730 Mt in 2013, with a recent decline to approximately 670 Mt in 2015. Consumption more than doubled over the last decade with an average annual growth rate of approximately 8.5% from 2005 to 2015, including the 2014 and 2015 decline.

The global steel consumption increased by approximately 470 Mt over the period from 2005 to 2015 for which China accounts for approximately 350 Mt or 73% and India for approximately 40 Mt or 9%. Collectively China and India account for more than 80% of the global steel consumption growth, with China being the single largest contributor by a long way. It is thus conclusive that the last decade's significant increase in the demand for steel was driven by China's rapid economic development and urbanisation (MESTEEL, 2016).

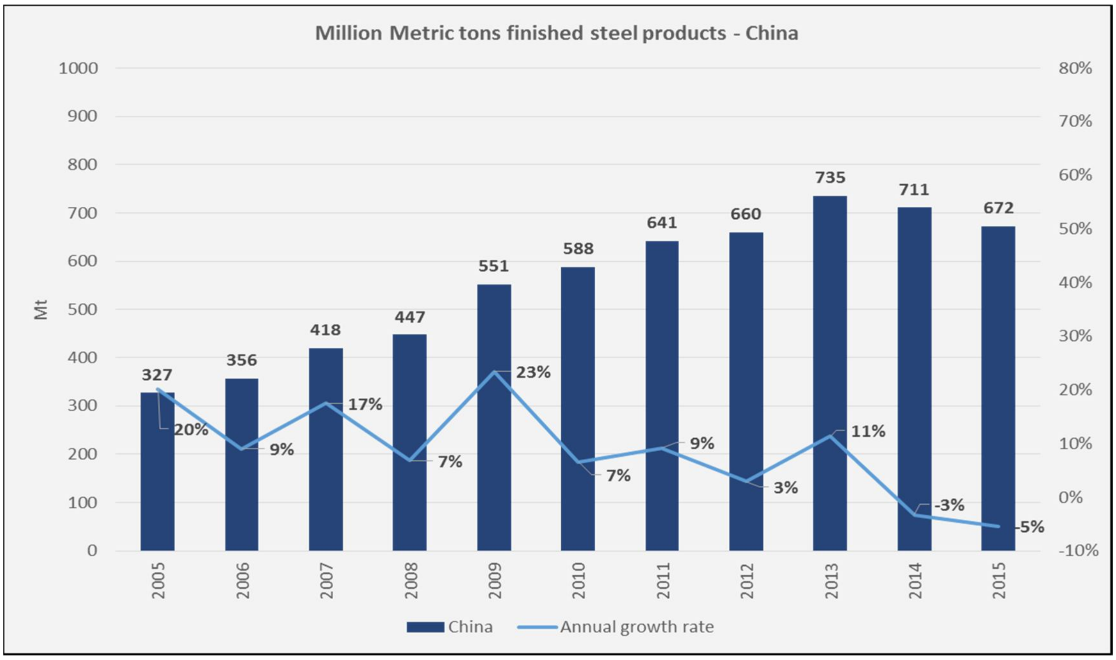

Figure 3.6: Apparent steel consumption, China (MESTEEL, 2016)

Figure 3.7 provides a summary of the apparent steel consumption for the top 10 countries for 2005 by contribution. China was consuming approximately 32% of the global consumption, with the USA in 2nd place with an annual consumption of approximately 10%. Japan was in 3rd place with an annual consumption of approximately 8%. The remainder of the top 10 was 5% or less. This clearly demonstrates the significance of China from as early as 2005 (MESTEEL, 2016).

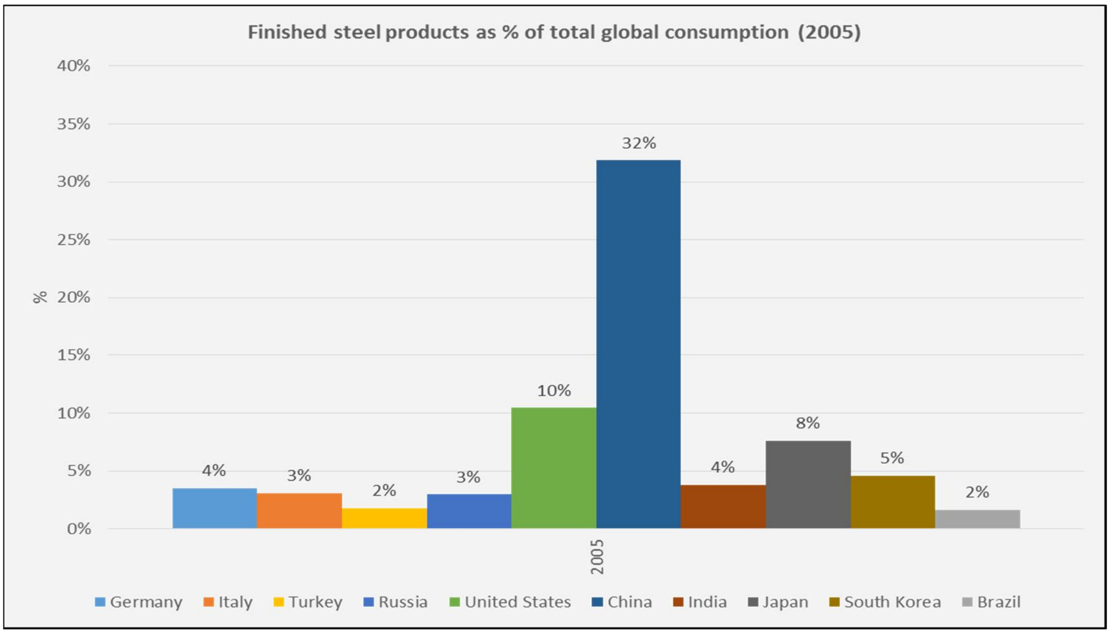

Figure 3.7: Apparent steel consumption by top 10 countries 2005 (MESTEEL, 2016)

Figure 3.8 provides a summary of the top 10 economies by apparent steel consumption for 2015. China's consumption increased to approximately 45% of the global consumption from 32% in 2005, with the USA reducing to approximately 6%, down from 10% in 2005. The third largest steel consumer was India at about 5%, displacing Japan and South Korea over the last decade who previously occupied the 3rd and 4th place. As for Germany, Russia, Italy, Turkey and Brazil, as part of the top 10 steel consuming economies, their significance were diluted by the significant growth of China over the last decade (MESTEEL, 2016).

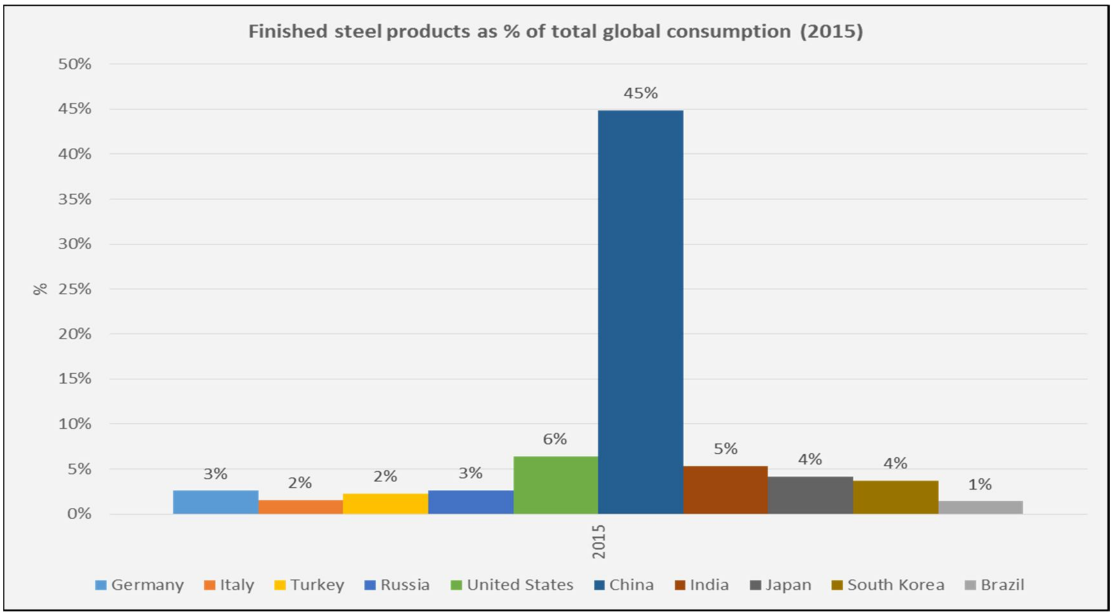

Figure 3.8: Apparent steel consumption by top 10 countries 2015 (MESTEEL, 2016)

3.6 Steel consumption per capita

Steel consumption per capita is a measure of economic activity, which is an important driver for economic growth and ultimately economic development. As per Cuddington and Jerrett (2008), as well as Erten and Ocampo (2012), the super cycles for commodities were driven by the resurgence of Europe post World War II, the industrialisation of the USA, Japan and more recently, China. Consideration is given to the steel consumption per capita for the said key economies.

The top four countries by apparent steel consumption in 2015 were China, USA, India and Japan, in that order, and collectively consumed approximately 60% of global steel. Figure 3.9 provides a summary of the apparent steel consumption per capita for the world and the top four consuming countries from 2005 to 2015. Given the fact that global apparent consumption of steel increased by approximately 46% over the period 2005 to 2015, while the global population only increased by 13%, the global apparent consumption of steel per capita increased by approximately 30%, which is significant.

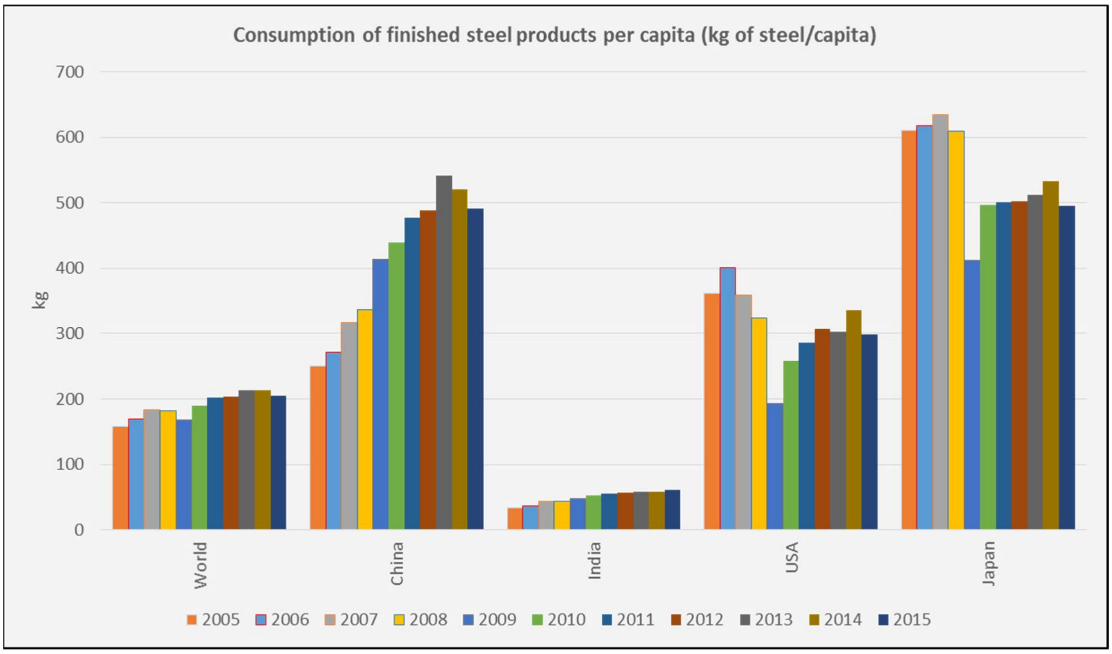

Figure 3.9: Apparent steel consumption per capita 2005-2015 (MESTEEL, 2016; The World Bank, 2016)

As per Figure 3.5 and 3.6, the increase in apparent steel consumption is predominantly driven by China's consumption. For the period from 2005 to 2015, the apparent steel consumption per capita decreased for both the USA and Japan by approximately 18% and 19%, respectively. As for India, the increase was approximately 77% and China approximately 96%. Although the base consumption for India is still low, when compared to China and some of the larger consumers, the growth rate is seen to be significant.

The GFC of 2008/09 had a material impact on the USA and Japan but nothing noticeable for India and China. Both the USA and Japan have not reached pre-GFC consumption levels. Consumption was lower for the year 2015, when compared to the previous years for most of the major economies and in particular for China, USA and Japan. China indicated a regression from 2014, resulting in the global consumption per capita to remain flat from 2013 to 2014.

3.7 Industrialisation and urbanisation of key economies

According to Elliot (2014), there is a clear link between steel consumption and urbanisation. Vast quantities of materials are required to develop cities and related infrastructure such as roads, power reticulation, etc. According to Romer (2016), there is a very high level of correlation between urbanisation and increasing economic growth, measured as GDP per capita. From Figure 3.10, global urbanisation increased by approximately 10% over the 25-year period from low 40% to 50%.

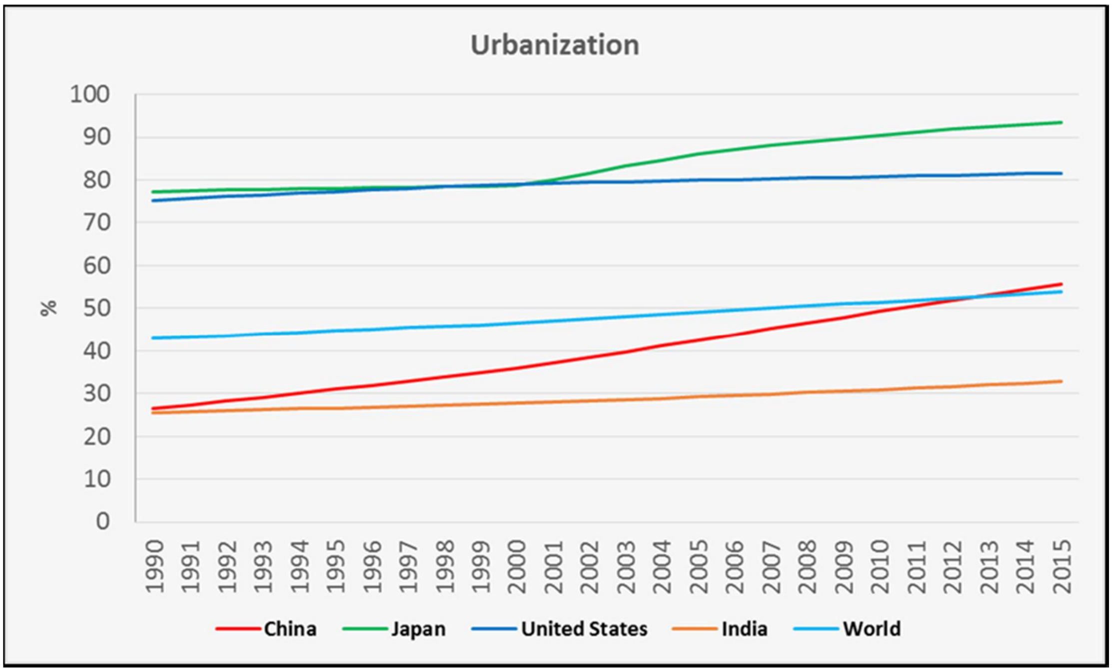

Figure 3.10: Urbanization of key economies 1990-2015 (The World Bank, 2016)

According to the World Bank (2016), China and India have the largest population highlighting the impact of a small percentage of industrialisation. From Figure 3.10, China's urbanisation increased significantly over the 25-year period by 30% to 56% by 2015. India is not nearly as significant at an increase of 7% over the same period. As for the two largest developed economies, namely the USA and Japan, the increase in urbanisation were 7% for the USA and 16% for Japan. The current levels of urbanisation for the USA is high at approximately 80% and even higher for Japan at just over 90%. It is evident how significant China is in terms of the rate or urbanisation and the impact on China's GDP/capita over the said period.

According to Gunter (2016), economic growth refers to an increase in GDP, whereas economic development refers to a structural change of an economy. The states of development refer to a structural transformation of the economy, a demographic transition and urbanisation. The structural transformation refers to the shift from agriculture to manufacturing and industrialisation to a services sector. The demographic transition mostly refers to fertility rates and changes in life expectancy.

According to the World Bank (2016), there are three major sectors contributing to the economy, namely: agriculture, industry and services. Agriculture consists of fishing, hunting, forestry, cultivation of crops and livestock. Industry includes, but is not limited to, mining, manufacturing, construction, electricity, water and gas. As for services, it includes wholesale and retail trade, transport, financial, government, professional and education. Figure 3.11 provides an overview of China's stage of economic development with the three sectors shown in terms of contribution.

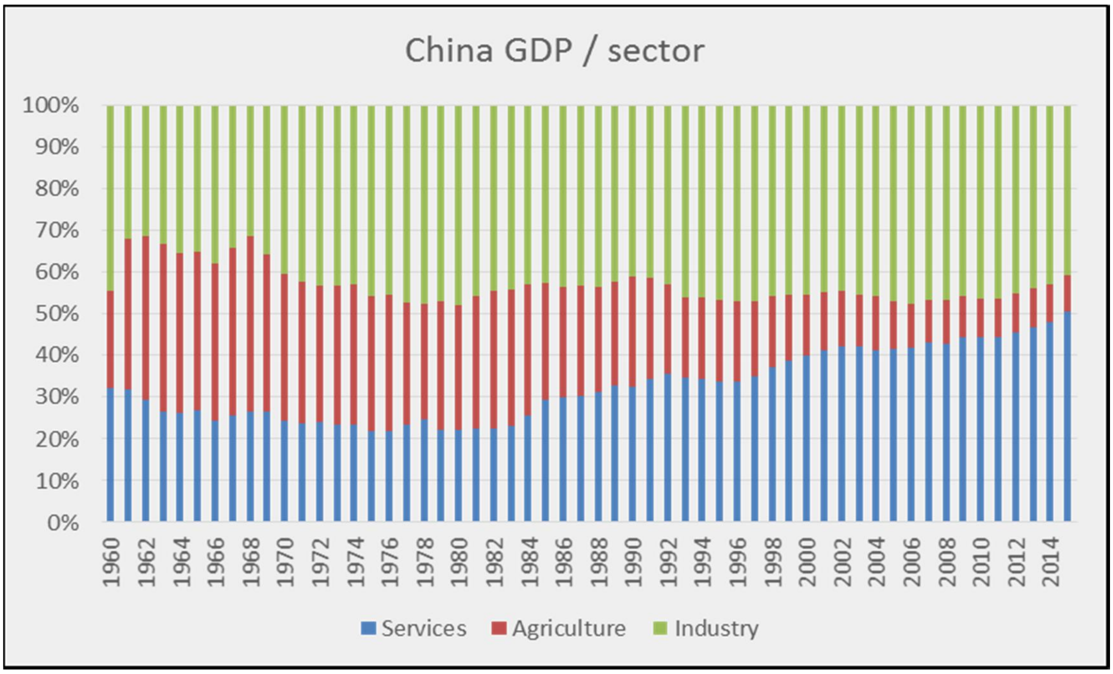

Figure 3.11: China's stage of economic development (The World Bank, 2016)

From Figure 3.11, China's GDP was made up of agriculture (~40%), industry (~35%) and services (~25%) during the 1960s. Industry's contribution to GDP increased significantly from the early 60s (~35%) to the early 80s (~48%). It remained relatively stable up to 2012 (~46%) with a slight reduction thereafter at a rate of approximately 1% per year to approximately 41% in 2015. As for agriculture's contribution to GDP, there was a constant decline over time from approximately 40% during the early 60s to approximately 9% during 2015. With regard to the services sector contribution, there is reasonable correlation between the increase in industry and decrease in services from the early 60s to the early 80s. From the early 80s there was a steady increase in contribution form the services sector with a 50% contribution during 2015. The GDP is predominantly driven by the industry and services sector and there is most definitely a shift towards a services sector economy consistent with developed economies. The stage of economic development for India as the second largest developing economy with the second largest population is shown in Figure 3.12.

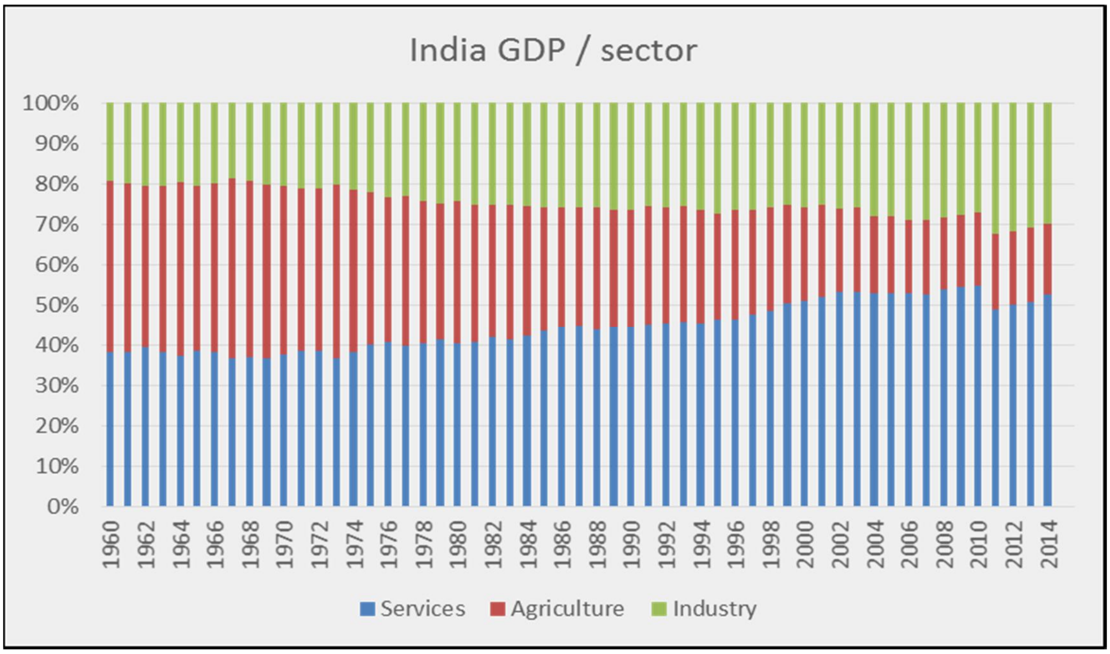

Figure 3.12: India's stage of economic development (The World Bank, 2016)

From Figure 3.12, the GDP contribution per sector during the early 60s were made up of agriculture (40%), industry (20%) and services (40%). In comparison to China, the increase in contribution from industry increased at a slower and stable rate over the said period from approximately 20% (1960) to approximately 30% (2015). The same applies to the services sector with an increase from approximately 40% (1960) to 50% (2015). Agriculture reduced from approximately 40% (1960) to 20% (2015). India is not yet driving rapid urbanisation nor industrialisation. The economic transition for India is much slower and stable when compared to China over the same period.

In order to have a good understanding of the stage of economic development for both China and India as the largest and 2nd largest developing economy respectively, a comparison with developed economies is drawn. Japan, as the second largest developed economy, GDP contribution per sector is summarised in Figure 3.13.

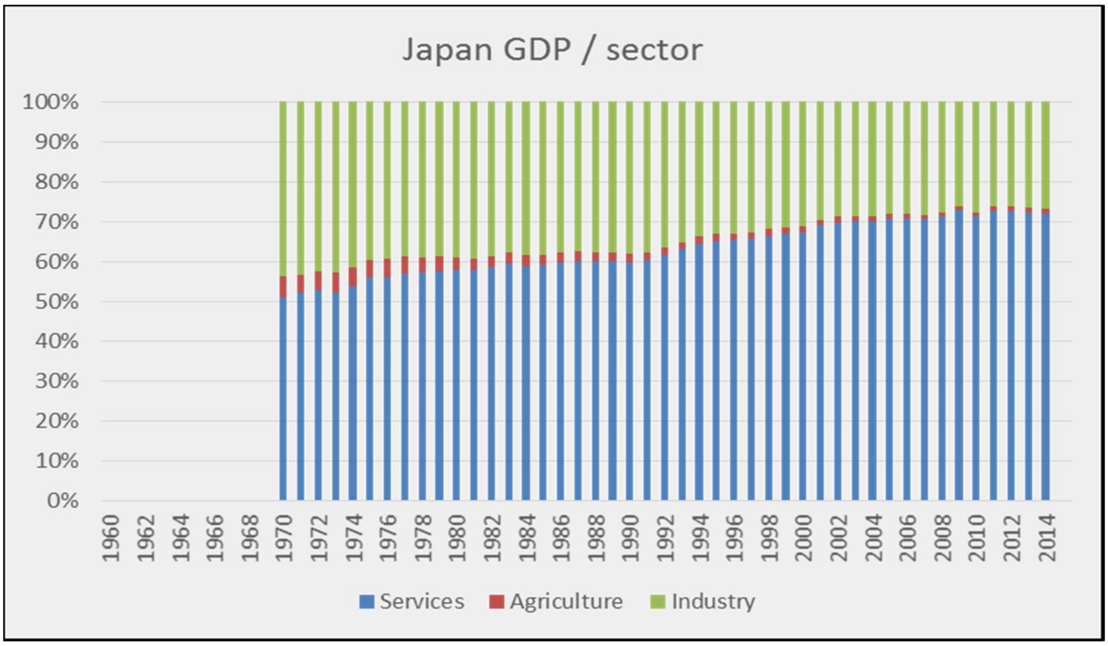

Figure 3.13: Japan's stage of economic development (The World Bank, 2016)

Japan as a developed economy relies heavily on services at more than 70% and industry at less than 30%, with agriculture being negligible in terms of GDP contribution per sector. Japan's services sector grew from approximately

50% in 1970 to 70% in 2015 at a reasonably stable rate. Agriculture was approximately 5% during 1970 and continued with the services sector resulting in a reduced industry sector from approximately 45% to 30%. As for the USA, as the largest developed economy (Figure 3.14), the GDP contribution per sector has been stable over the last 20 years with services at approximately 80%, industry at 20% and agriculture negligible. The GDP contribution per sector is very similar for Japan and the USA at almost 1% agriculture contribution, with 70% to 80% dependence on services.

When comparing Japan and the USA as the two largest developed economies to China and India as the largest emerging economies, the differentiator in terms of GDP contribution per sector appears to be the dependence on manufacturing and agriculture. Although China is much less dependent on agriculture, it still has a long way to go before the GDP per sector represents a developed economy like Japan or the USA.

India is progressing towards a services economy with the dependence on services and industry increasing and the dependence on agriculture decreasing. India has not yet undergone a material industrialisation drive, required to stimulate economic growth. There is also recognition that the stage of economic development is linked to GDP and GDP/capita.

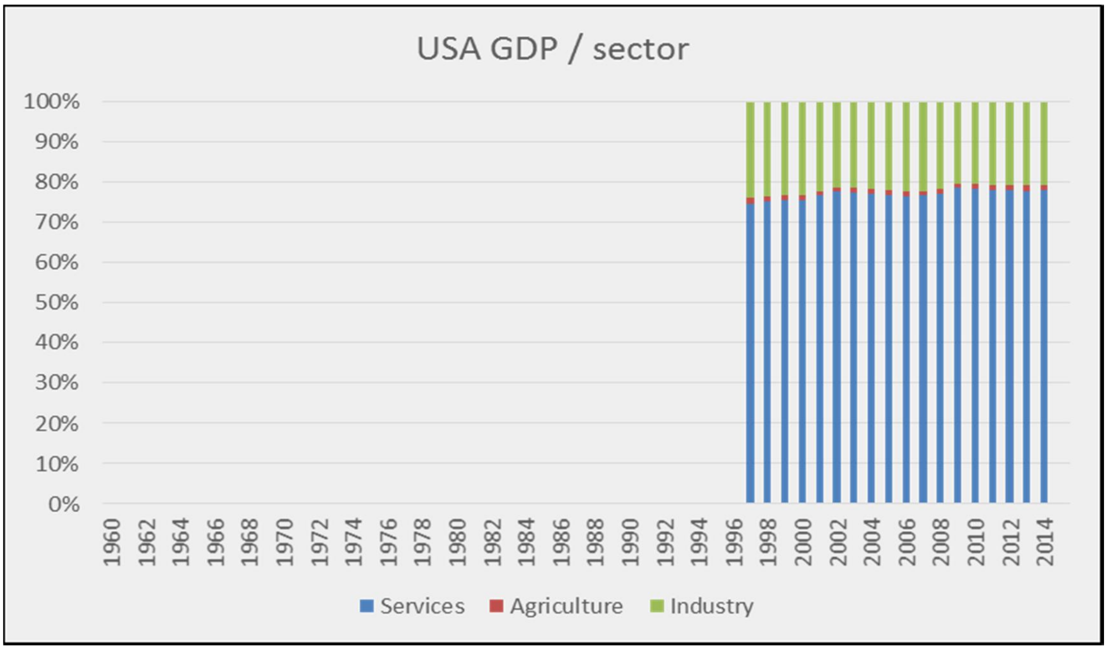

Figure 3.14: USA's stage of economic development (The World Bank, 2016)

3.8 Global steel production (supply)

The total production of world steel, also defined as global steel supply, is summarised in Figure 3.15 with a clear differentiation between China and the rest of the world. Steel is produced in more than 90 countries spread across the globe. The top 10 countries by production accounted for more than 80% of the world supply during 2015. These countries are summarised as China, Japan, India, USA, Russia, South Korea, Germany, Brazil, Turkey and the Ukraine from the biggest to the smallest contribution (Worldsteel Association, 2010-2016).

From Figure 3.15, it is evident that the global supply of steel increased significantly over the period 2005 to 2015 from 1.15 Bt to 1.6Bt. That is an increase of 41% over a ten-year period. The production from all producing countries, with the exclusion of China, remained stable with an insignificant increase of 3% over the said period. China, on the other hand, is almost solely responsible for the global increase in supply. Some of the smaller countries increased production significantly but due to the low base, this is insignificant from a global perspective. China increased steel production by approximately

450 Mt, an increase of 126% over the said period (Worldsteel Association, 2010-2016).

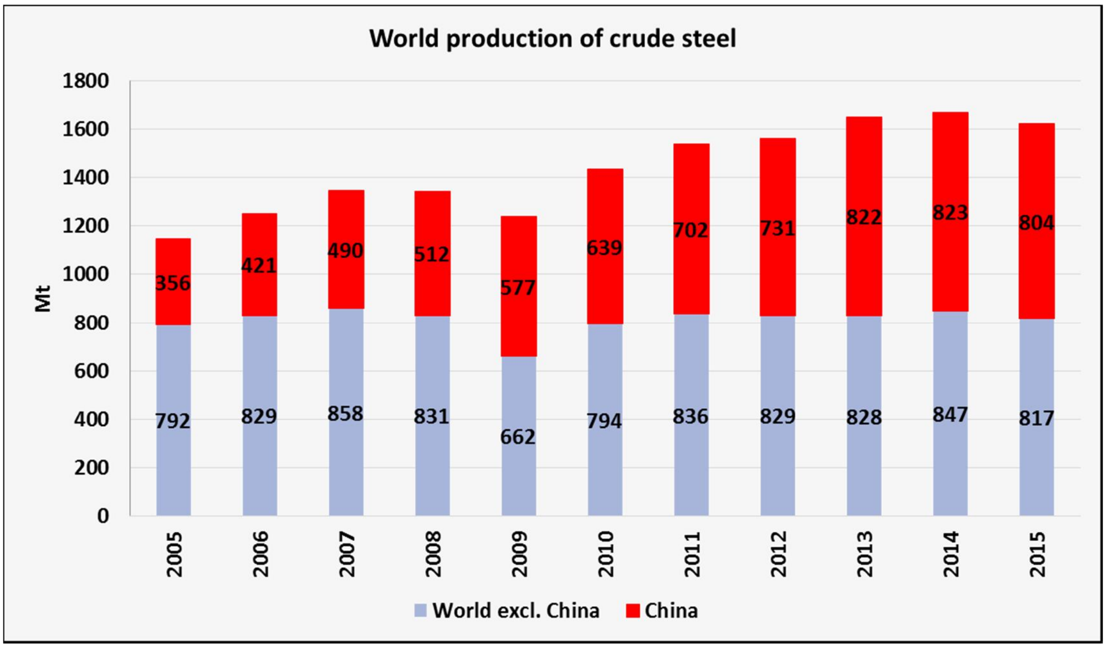

Figure 3.15: Global steel production (Worldsteel Association, 2010-2016)

Table 3.2 provides a summary of the top 15 steel producing countries, using 2015 as the basis for the ranking. Japan, as the second largest producer, following China, underwent a reduction in supply from 2005 (112 Mt) to 2015 (105 Mt). India went from the sixth largest supplier in 2005 producing 46 Mt to the third largest supplier in 2015 producing 89 Mt, effectively doubling production over the ten-year period. The USA reduced production and went from being the third largest producer in 2005 (95 Mt) to the fourth largest producer in 2015 (79 Mt). Russia being the fourth largest producer in 2005 (66 Mt) increased production to 71 Mt in 2015 making it the fifth largest producer (Worldsteel Association, 2010-2016).

Table 3.2: Top 15 steel producing countries, 2015 basis (Worldsteel Association, 2010-2016)

	Production per annum (Mt)			% of global production	
	2005	2015	% Growth 2005-2015	2005	2015
China	356	804	126%	31%	50%
Japan	112	105	-6%	10%	6%
India	46	89	95%	4%	6%
United States	95	79	-17%	8%	5%
Russia	66	71	7%	6%	4%
South Korea	48	70	46%	4%	4%
Germany	45	43	-4%	4%	3%
Brazil	32	33	5%	3%	2%
Turkey	21	32	50%	2%	2%
Ukraine	39	23	-40%	3%	1%
Italy	29	22	-25%	3%	1%
Taiwan, China	19	21	13%	2%	1%
Mexico	16	18	12%	1%	1%
Iran	9	16	71%	1%	1%
France	20	15	-23%	2%	1%

During 2005, China was the largest producer of world steel at 31%, with Japan being the second largest producer accounting for 10% of global supply and the USA in third place at 8%. During 2015, China produced 50% of the total global steel production with Japan and India both at 6% (Worldsteel Association, 2010-2016).

According to the Worldsteel Association (2010-2016), the top five steel producing companies based on 2015 data in order of descent, can be summarized as ArcelorMittal (97 Mt), Hesteel Group (47 Mt), Nippon Steel and Sumitomo Metal Corporation - NSSMC (46 Mt), POSCO (42 Mt) and Baosteel group (35 Mt). Considering all the steel producing companies with an annual output exceeding 3 Mt, there are more than 90 companies for consideration of which approximately 50 have their headquarters located in China. The significance of China is once again highlighted from a supply perspective, the growth over the period 2005 to 2015, and the number of steel producing company headquarters situated in China.

3.9 Global steel recycling and impact on supply and demand

Recycling of steel plays a fundamental role in the determination of demand for iron ore on a global scale. It will vary from region to region based on different fundamentals and economic drivers. For 2015, the total recycled steel used for steel production is more than 550 Mt per annum (Bureau of International Recycling, 2016). Steel is repeatedly recyclable with no impact on the properties of the end-product and the life is seen to be infinite.

According to SteelConstruction.info (2016), a study conducted in the United Kingdom (UK) suggests that the recovery rate of steel from buildings is approximately 96%, so, based on the availability of scrap, steel is almost 100% re-usable. Recycling of steel can follow one of two production routes. Firstly the primary of basic oxygen steelmaking route based on the reduction of iron ore. For this process, 10% to 15% of scrap metal is typically incorporated. The second production route is the secondary or electric arc furnace route which is 100% scrap based. Developed economies typically have a much better balance between demand and supply from recycling. Developing economies have a much higher need for iron ore to produce steel, since the availability of recycle steel is much lower. Based on data from the Worldsteel Association (2010-2016), the 2015 ratio of oxygen versus electric steel production was 75% to 25%. Steel recycling is limited by the availability of electric furnace capacity.

According to the world steel recycling in figures (2015), steel recycling as an input into the steel making process are primarily from three different sources, namely: own arising's (circulating scrap), new steel scrap (process scrap) and old steel scrap (capital scrap). Circulating scrap is produced in iron ore and steel plants and is easily accessible. This is approximately 13% of total crude steel production. New steel scrap originates from metalworking and manufacturing. This is essentially the steel that remains after manufacturing and which cannot be utilized for various reasons. Steel plants will need to buy back this steel from the manufacturers and is reasonably easy to come by. New scrap accounts up approximately 15% of finished steel goods. The qualities are also generally known, so it does not pose a quality challenge in the steel making process. As for old steel scrap, this is obsolete scrap from buildings, ships, cars, etc. Figure 3.16 provides a visual representation of the impact of scrap steel utilisation in steel manufacturing on the demand for iron ore based on 2015 data.

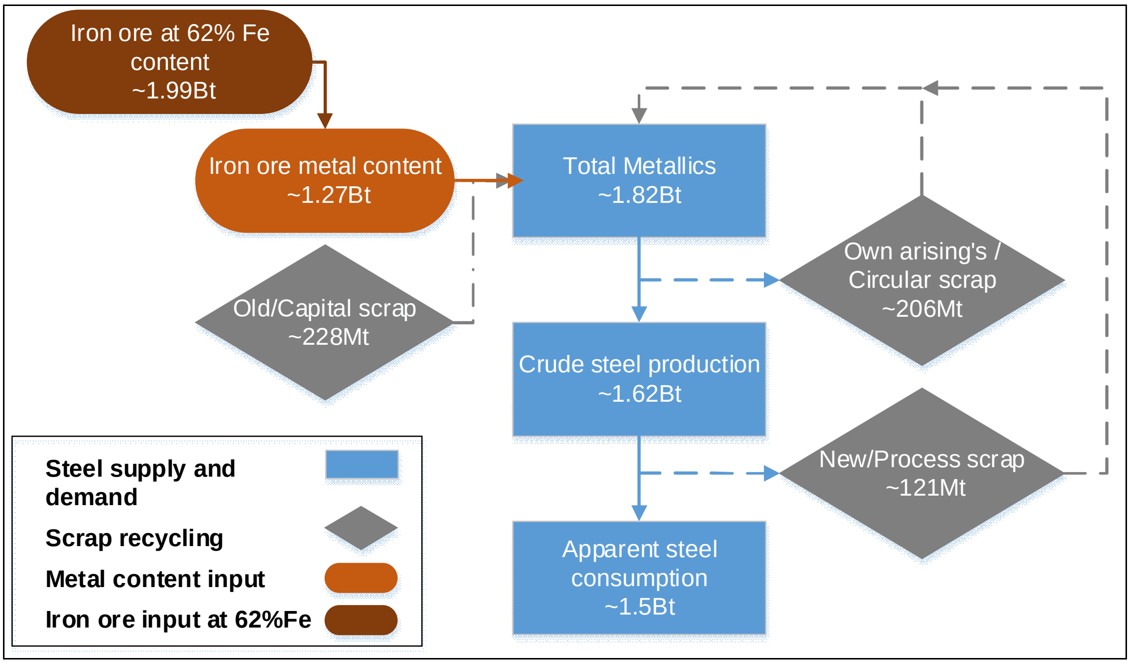

Figure 3.16: Global steel production and scrap steel consumption 2015 (Worldsteel association, 2010-2016; Bureau of Internaitonal Recycling, 2016)

As per figure 3.16, the total steel produced for 2015 was approximately 1.62 Bt from the total metallics of approximately 1.8 3Bt. The circular scrap accounted for approximately 206 Mt that keeps recycling in the system. The apparent steel consumption was approximately 1.5 Bt from the crude steel production of approximately 1.62 Bt resulting in approximately 121 Mt of new scrap. The old scrap introduced into the system accounted for approximately 228 Mt. The total amount of scrap steel consumption for 2015 was approximately 555 Mt. The iron ore required by metal content is also shown as approximately 1.27 Bt. When considering a normalized iron ore feed at the benchmark 62% Fe product specification, one would have required approximately 1.99 Bt of iron ore. Table 3.3 provides a summary of the total global steel production and recycling data over the period 2005 to 2015.

From Table 3.3, the scrap consumption increased from approximately 462 Mt (2005) to approximately 555 Mt (2015). The scrap steel consumption remained relatively stable from 2010 to 2015 at around 530 Mt to 580 Mt per year. The amount of recycled steel consumption is constrained by the availability of scrap steel, as well as the availability of capacity in electric arc furnaces. The amount of circular scrap used is directly linked to the crude steel production and was approximately 200 Mt per year from 2010 onwards. As for new scrap, arising predominantly from manufacturing, accounted for approximately 120 Mt from 2010. The circular scrap and new scrap essentially remain in the system with no direct impact on supply and demand. The scrap steel recycling component that directly influences the demand for iron ore, is the old scrap steel. Old scrap steel increased from the early 2000s and consumption ranged from 230 Mt to 250 Mt over the last five years.

To estimate the implied iron ore demand by metal content, one must consider all aspects of production and recycling. The implied iron ore demand on a metal content basis increased by approximately 48% over the period 2005 to 2015.

Table 3.3: Global steel production and recycling (2005 – 2015) (Worldsteel association, 2010-2016; Bureau of International Recycling, 2016)

	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Crude steel production	1 148	1 250	1 348	1 343	1 239	1 433	1 538	1 560	1 650	1 670	1 621
Total scrap use	462	500	540	530	440	530	570	570	580	585	555
Own arisings/Circular scrap	174	185	197	195	176	190	200	200	205	207	206
New/prompt scrap purchases (process scrap)	122	109	107	105	90	110	120	120	130	133	121
Old steel scrap (discarded steel scrap)	166	206	236	230	175	230	250	250	245	245	228
Total Metalics (primary iron + steel scrap + DRI)	1322	1440	1568	1547	1437	1634	1748	1767	1862	1882	1827
Apparent steel consumption	1 026	1 113	1 220	1 226	1 151	1 310	1 415	1 443	1 534	1 546	1 500
Implied metal content demand from iron ore	860	907	984	996	976	1 080	1 165	1 193	1 289	1 301	1 272
Implied iron ore demand @ 62% Fe benchmark	1 346	1 419	1 539	1 558	1 527	1 690	1 823	1 866	2 017	2 035	1 990

3.10 Global steel supply and demand balance

From Figure 3.17, the apparent steel consumption declined during the Global financial crisis (GFC) of 2008/2009 and again in 2015. The correlation between supply and demand is reasonably high with no clear signs of significant over production as is shown in Figure 3.17. On that basis, it would appear that the supply side reacted reasonably fast to the contraction in demand. As discussed previously, the recycled new scrap is steel which cannot be used for manufacturing for various reasons, also referred to as wastage. On average, the recycled new scrap makes up approximately 121 Mt per annum or approximately 8% of the apparent steel use. Over the ten-year period the implied over supply as a percentage of apparent steel maintained a range of -1% to +3%.

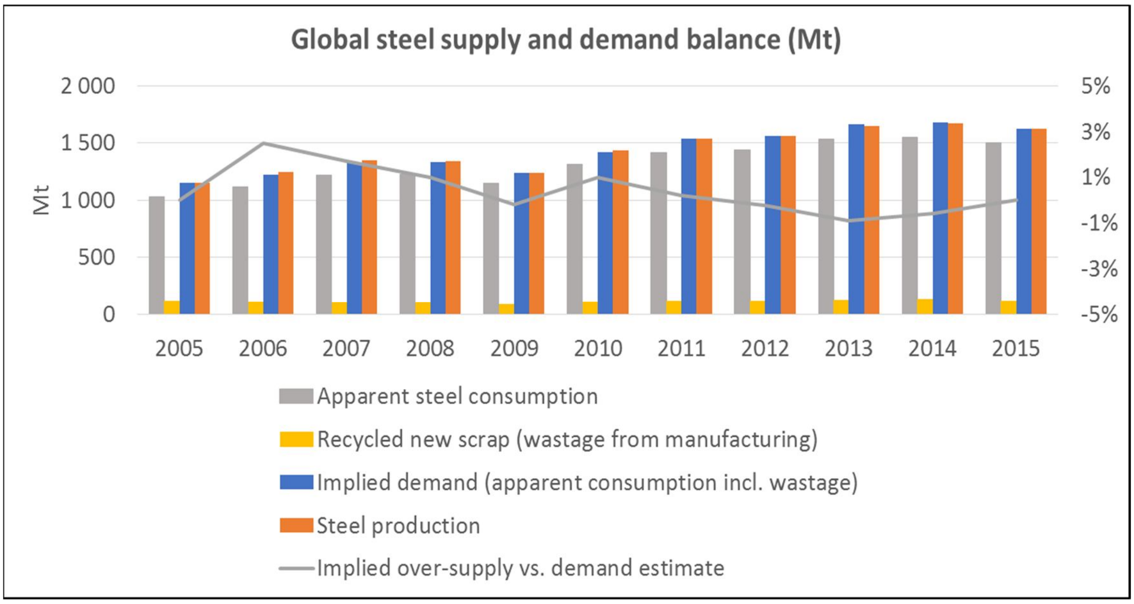

Figure 3.17: Global steel supply and demand balance (Worldsteel association, 2010-2016; Bureau of Internaitonal Recycling, 2016)

3.11 Global iron ore demand key economies

Apparent steel consumption is used as an indicator for iron ore demand. The demand for iron ore (stated in tonnes) is, however, dependant on the grade of iron ore being produced. Iron ore grades varying from as low as 20% to as high as 67% are produced globally due to various geological formations and processing capability (USGS, 2016).

Iron ore is blended at various locations to meet the required iron ore quality for the furnace in question due to various technical and environmental reasons. China's iron ore is of particular low quality with Fe qualities of between 17%

and 20% not that uncommon. The global average iron ore product grade is 62% with the Australian producers averaging a product specification of 60%. The impurities are also an important factor; hence, it is not only the Fe but also the impurities that matter and is considered for price normalisation (Iron ore facts, 2016).

As per the summary provided in Table 3.2, China produced approximately 50% of the global steel during 2015, with Japan and India following at approximately 6% each. Japan and India were then followed by the USA at 5%, Russia at 4% and South Korea at 4%. (Worldsteel Association, 2010-2016). China is also the largest importer of iron ore in the world, since the demand cannot be met from its local supply. As discussed previously, the quality of iron ore will impact the tonnage of iron ore required to produce the required steel. It is estimated that the weighted average iron required for steel making, is approximately 97% based on the USGS (2013) contribution per steel type and estimated iron content per steel type according to specification. Various sources state iron ore production tonnages in different quality specifications presenting some challenges with direct comparison. Table 3.3 provides a summary of the steel supply and demand, as well as the implied iron ore demand normalised to a 62% Fe product specification. The derived iron ore demand for 2015 was approximately 2 Bt (62% Fe), a slight reduction from the previous two years.

Since China is the largest consumer of iron ore by a significant margin, the Chinese iron ore imports provide good insight into the demand for seaborne iron ore. Figure 3.18 provides a summary of the iron ore imports for China at an estimated rate of 950 Mt 2015. The left hand scale represents monthly data and the right hand scale rolling annual data. Sourcing data to quantify the total iron ore stock carried across the value chain, proved to be a major challenge due to the size of the market. From Figure 3.18, the iron ore imports increased at a reasonably stable rate over the period, but slowed down from late 2014 throughout 2015, with a spike in December 2015 (Business Insider Australia, 2016).

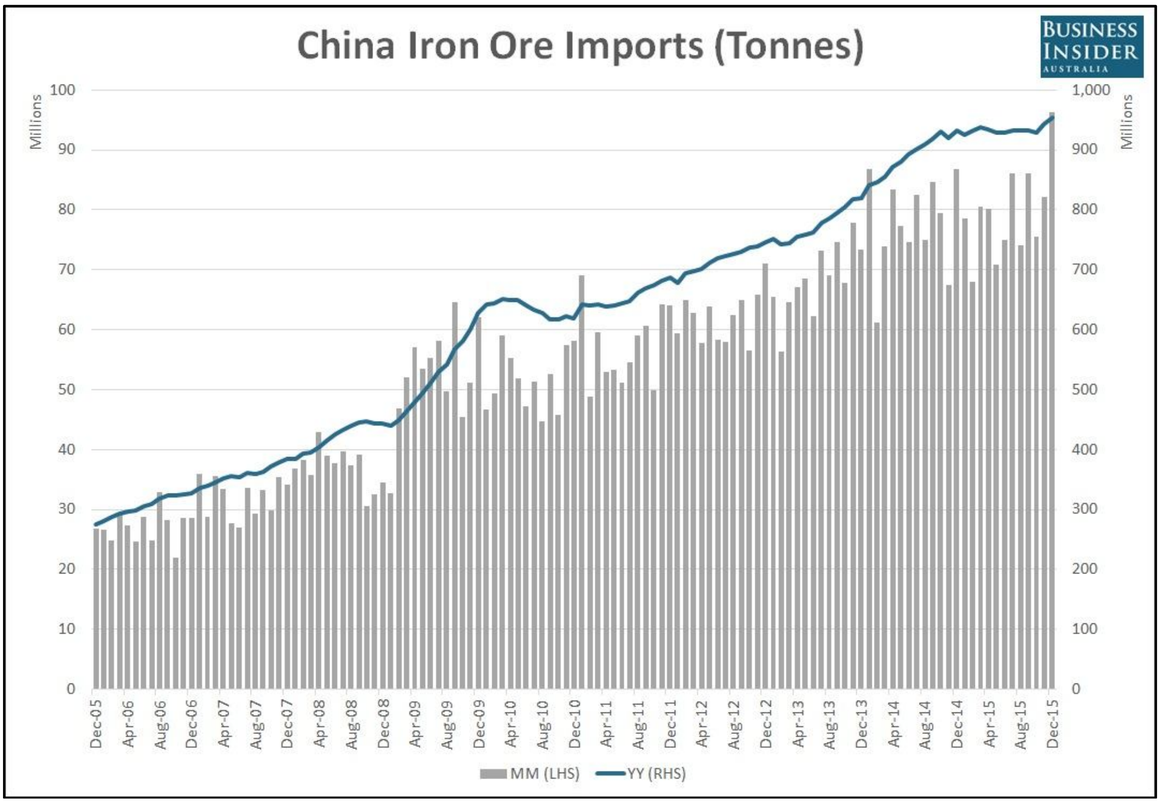

Figure 3.18: China iron ore imports from 2005 to 2015 (Business Insider Australia, 2016)

3.12 Global iron ore supply by key economies

The two primary data sources used for global iron ore supply are the United States Geological Survey (USGS) and the Worldsteel Association based on data from the United Nations. Various sources report iron ore mining production in different ways, primarily because of the normalisation of iron ore product specification. The IODEX iron ore fines 62% Fe ($/DMT) benchmark price is based on a 62% Fe fines product, although prices are also published for a low-grade 58% Fe, high-grade 65% Fe and a 63% / 63.5% Fe product. Depending on the product specification, mainly because of the stage of beneficiation, production numbers will vary for various data sources. For example, the USGS (2016) reported the total global annual production of iron ore as 3.4 Bt (2014) and 3.3 Bt (2015). Worldsteel Association (2010-2016) reported the total global annual production of iron ore as 2 Bt (2014), adjusted for the world average iron content highlighting the different approaches.

Chinese iron ore production, as a very significant global contributor at 1.4 Bt (2015) and 1.5 Bt (2014), is stated as crude ore rather than usable ore (USGS, 2016). As discussed previously, a significant portion of the Chinese iron ore production is of very low quality and one must take caution when using these numbers as pure supply. The definition for “crude ore” is “the ore as it leaves the mine in un-concentrated form” (The Free Dictionary by Farlex, n.d.). According to information from the Worldsteel Association (2010-2016), global production of iron ore for 2014 was approximately 2 Bt. Chinese production is stated as 193 Mt. The 193 Mt of production form China is an adjusted figure based on the world average Fe content because of the very low quality specification. Using iron ore production data without quantifying the impact of various grades and associated beneficiation losses will skew the supply and demand fundamentals.

Figure 3.19 provides a summary of the global iron ore production per country over the period 2005 to 2015 based on data from the USGS (2016). The top nine countries accounted for approximately 95% of iron ore by gross weight with the top three countries, namely China, Australia and Brazil, at approximately 80% of global output. The total global annual production by gross weight increased by approximately 115% from 1.5 Bt (2005) to 3.3 Bt (2015) at an average annual growth rate of 7.8%. The total global production, excluding the top three producing countries, increased by an insignificant amount of approximately 100 Mt from approximately 587 Mt (2005) to 688 Mt (2015) over the ten year period and is seen to be relatively stable as such (USGS, 2016).

The three largest iron ore producing economies experienced significant growth over the ten-year period to the amount of approximately 1.67 Bt, effectively doubling production. Brazil was the second largest producer after China in 2005, but was overtaken by Australia in 2009. Over the ten-year period, Brazil increased output by approximately 150 Mt, Australia by approximately 560 Mt and China by a staggering 960 Mt, making it the largest producer by a long way. It is, however, important to highlight the production from China is at a much lower quality compared to the other global producers making it difficult to compare (USGS, 2016). The cost of production is also very important as it is directly linked to the iron ore price and production levels. The cost of production will be elaborated on in chapter four with the analysis of the industry cost curves as well as the four majors.

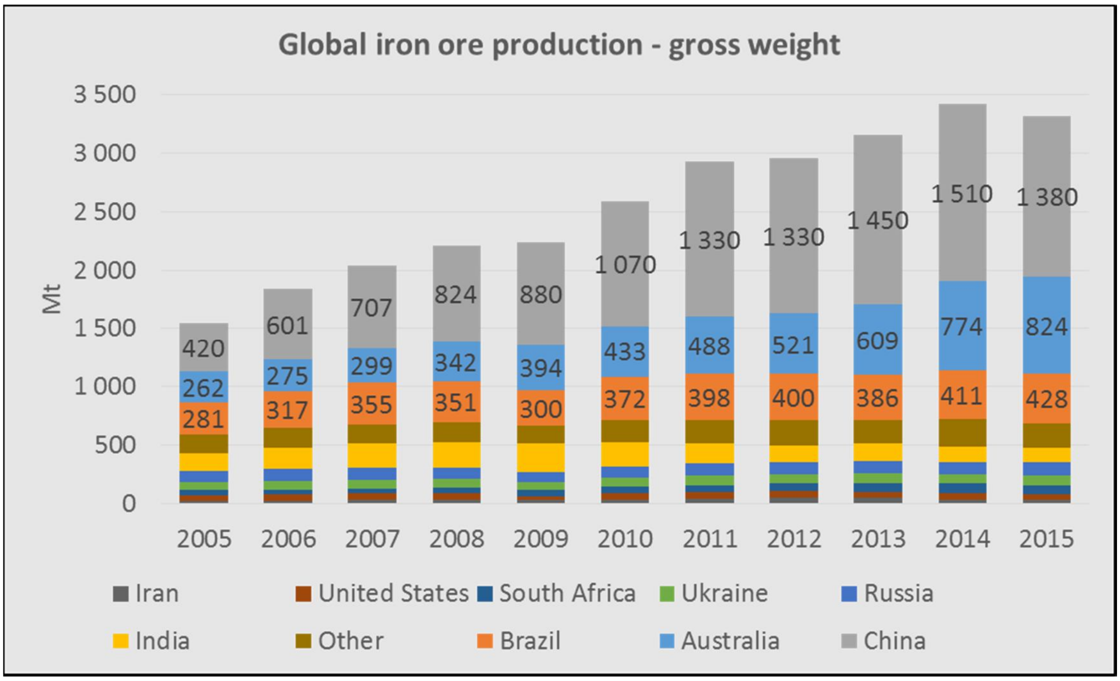

Figure 3.19: Iron ore production per region from 2005 to 2015 (USGS, 2016)

The metal content is key in understanding supply, as there is a direct correlation with steel production, since it is all about the iron contained in the ore. It is essentially the tonnes of iron contained in the iron ore. Iron ore grade is specified as % Fe. Table 3.4 provides a summary of the iron ore grades, stated as % Fe applicable to the gross weight data presented in Figure 3.20. The data from 2005 to 2013 is extracted from the USGS (2016). As for 2014 and 2015, the grades were extrapolated due to data not being available for the two years. The global average grade reduced from 54% (2005) to 47% (2013). The top nine countries are considered as they make up 95% of global supply.

Australia's iron ore grades ranged between 57% and 65% over the ten-year period with an average of 61%. Brazil's iron ore grades, ranged between 64% and 67% with an average of 66%. As for China, the iron ore grades ranged between 30% and 33%, are very low according to world standards, and considering the significant contribution in terms of total tonnes produced it is very significant. The average iron ore grades for the other key producing economies over the said period were: India 64%, Russia 58%, Ukraine 55%, South Africa 64%, USA 63% and Iran 48%. South Africa had the highest extrapolated iron ore grades for 2014 and 2015 at 65% as per table 3.4 (USGS, 2016).

Table 3.4 Iron ore grade (% Fe) applicable to gross weight from 2005 to 2015 (USGS, 2016)

	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Australia	62%	62%	65%	61%	58%	63%	57%	60%	62%	62%	62%
Brazil	67%	67%	66%	66%	66%	67%	67%	65%	64%	64%	64%
China	33%	33%	33%	33%	32%	31%	31%	30%	30%	30%	30%
India	64%	65%	64%	65%	64%	64%	64%	64%	64%	64%	64%
Russia	58%	58%	58%	58%	58%	59%	59%	59%	58%	58%	58%
Ukraine	55%	55%	55%	55%	56%	55%	54%	55%	55%	55%	55%
South Africa	63%	63%	65%	63%	65%	63%	64%	64%	65%	65%	65%
United States	63%	63%	63%	63%	64%	62%	62%	61%	62%	62%	62%
Iran	47%	50%	47%	47%	48%	49%	48%	48%	48%	48%	48%
Other	61%	59%	59%	59%	59%	59%	59%	57%	57%	57%	57%
Total	54%	53%	52%	51%	50%	49%	47%	47%	47%	47%	47%

As eluded to previously, the iron ore metal content essentially provides a view of the total metal produced from the said iron ore and makes it comparable from an output perspective. Figure 3.20 provides a summary of the iron metal content produced globally by major contributor over the period 2005 to 2015. The annual output in terms of metal content is significantly lower in comparison with the iron ore output, because of some lower quality ores making its way into the market. That being said, the annual increase in output over the ten-year period was still very significant, from approximately 850 Mt during 2005 to approximately 1.55 Bt during 2015 (USGS, 2016).

The annual output increased by 82% over the said period at an average annual rate of 6%, which is significantly lower than the 7.8% increase in total iron ore output. During 2005, the production for the top three producers was evenly distributed. The largest producer for 2005 by metal content was Brazil, with Australia the second largest and China in third place. By 2015, the rankings changes significantly with Australia as the largest producer, China in second place and Brazil in third. Brazil increased output by 85 Mt, Australia by 350 Mt and China by 280 Mt. On a metal content basis, Australia produced the highest output and grew the most over the ten-year period. There was almost no change in total collective output from the other producers (USGS, 2016).

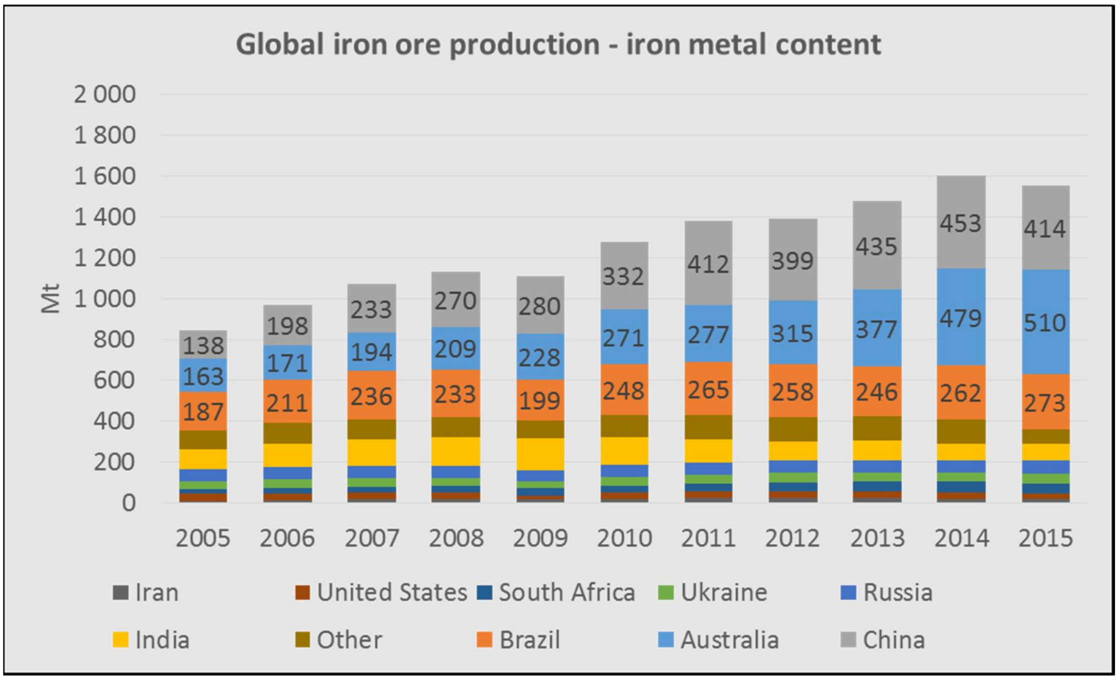

Figure 3.20: Iron ore metal content production by country from 2005 to 2015 (USGS, 2016)

When one excludes China's iron ore production, the average global iron ore grade is 62%, correlating very well with the IODEX iron ore fines 62% Fe ($/DMT) benchmark specification. The data sourced from the USGS (2016), normalized to a 62% Fe product specification, is summarized in Figure 3.21. The normalised tonnes do not account for further beneficiation losses and is possibly overstated as a result. The adjusted iron ore output increased from 1.35 Bt (2005) to 2.5 Bt (2015). The iron ore supply can be adjusted to a wide range of product specifications; however, for ease of use and consistency throughout this research report, the 62% Fe reference is used (USGS, 2016).

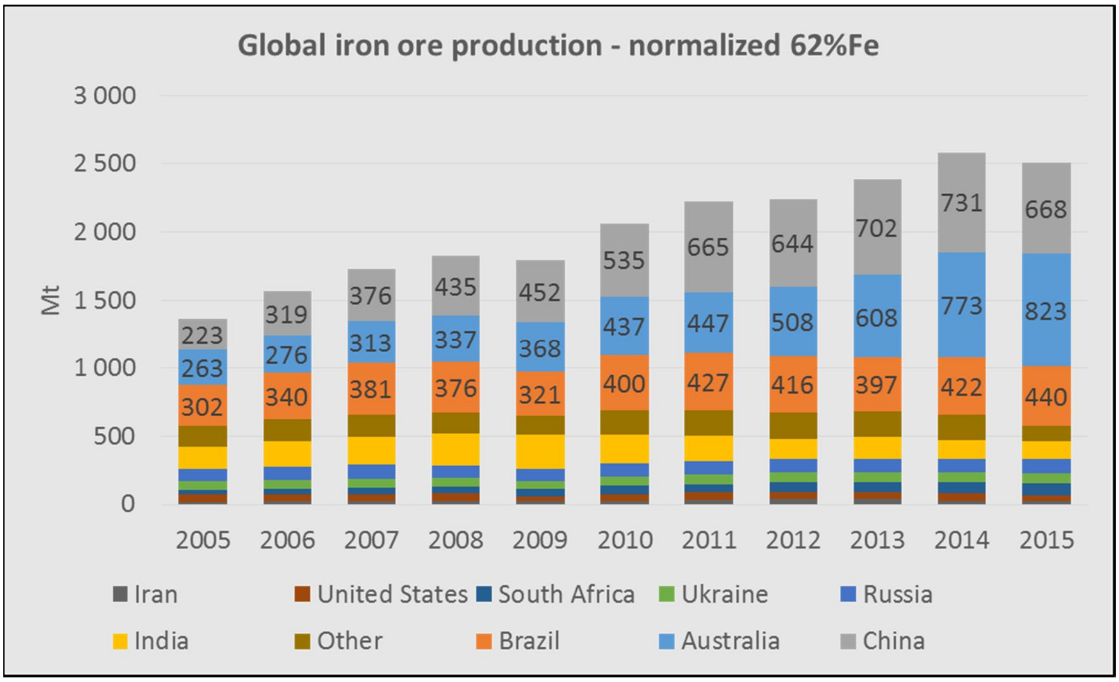

Figure 3.21: Global iron ore production at 62% Fe specification from 2005 to 2015 (USGS, 2016)

3.13 Global iron ore supply by key companies

The four largest iron ore producers are Vale, RIO, BHP and FMG, in that order. Figure 3.22 provides an overview of the annual output per company over the period 2005 to 2015. For 2005, Vale was the largest producer at 233 Mt of iron ore, with RIO the second largest at 124 Mt and BHP the third largest at 96 Mt. The three companies collectively produced 450 Mt of iron ore and the contribution was 30% of global output. The iron ore output from Vale increased by 110 Mt over the said period with the output from RIO increasing by 140 Mt, BHP by 135 Mt. As for FMG, production commenced late 2008 and grew at a rapid rate to 164 Mt output by 2015. By 2015, the four largest producers collectively accounted for 1.0 Bt of the total iron ore output out of 2.5 Bt (62% Fe); being responsible for 40% of global iron ore output.[2]

[2]Source data: BHP Billiton (2008), BHP Billiton (2010), BHP Billiton (2012), BHP Billiton (2014), BHP Billiton (2016), Rio Tinto (2008), Rio Tinto (2010), Rio Tinto (2012), Rio Tinto (2014), Rio Tinto (2016), Vale (2007), Vale (2009), Vale (2011), Vale (2013), Vale (2015), FMG (2008), FMG (2010), FMG (2012), FMG (2014), FMG (2016)

During the five-year period from 2010 to 2015, iron ore output was significantly increased by Vale's Northern System in Brazil (~30 Mt) and RIO's Hammersley mines in Australia (~75 Mt). As for BHP, production increased across the board, which included Newman, Area C, Yandi, Jimblebar, Wheelarra and Samarco mines (~110 Mt). FMG increase output by approximately 120 Mt over the same period with new mines coming into operation. The output from the largest mining companies indicates a steady increase in production from 2005 to 2013 with an exponential increase from 2013 to 2014.[3] The iron ore prices were still seen to be very high during 2013 and started to fall drastically from 2014, which coincides with the increase in output from the majors.

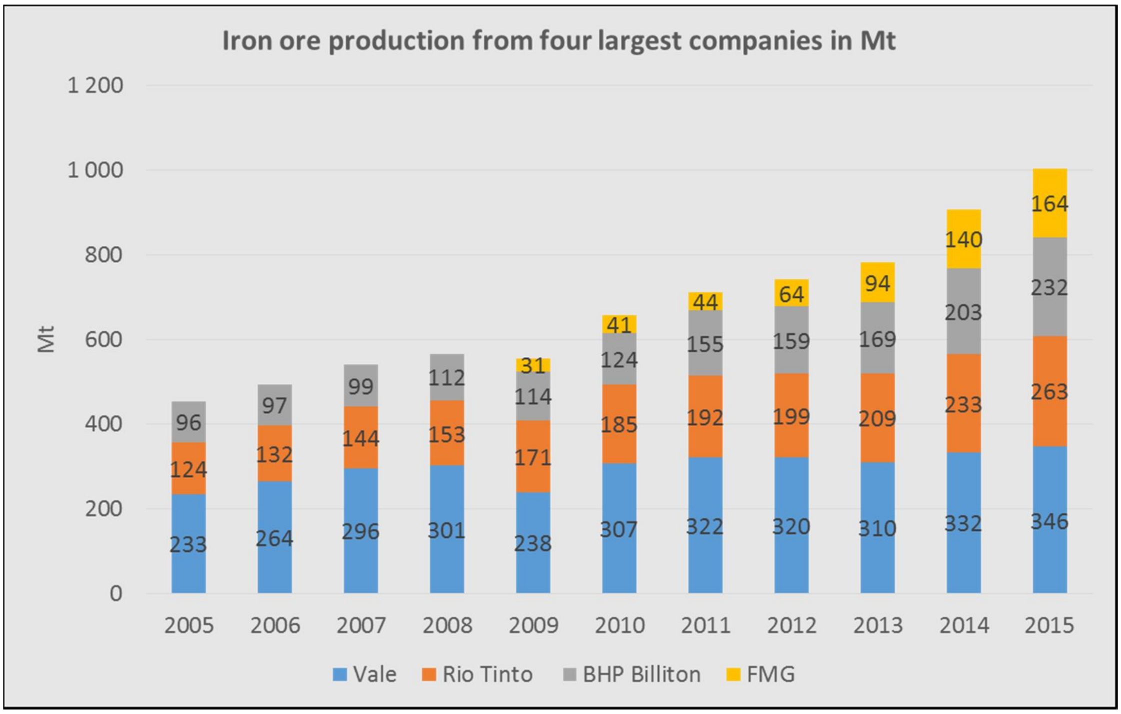

Figure 3.22: Iron ore production from four largest producers (2005 to 2015)[4]

[3],[4]Source data: BHP Billiton (2008), BHP Billiton (2010), BHP Billiton (2012), BHP Billiton (2014), BHP Billiton (2016), Rio Tinto (2008), Rio Tinto (2010), Rio Tinto (2012), Rio Tinto (2014), Rio Tinto (2016), Vale (2007), Vale (2009), Vale (2011), Vale (2013), Vale (2015), FMG (2008), FMG (2010), FMG (2012), FMG (2014), FMG (2016)

3.14 Iron ore supply and demand balance (2005 – 2015)

The total global iron ore exports were 1.5 Bt for 2015. The two largest exporting economies were Oceania at 810 Mt (54%) and South America at 400 Mt (27%); collectively with iron ore output at 1.2 Bt responsible for more than 80% of global exports (Worldsteel Association, 2010-2016). As per Figure 3.22, production from the four largest companies were 1 Bt for 2015 and correlates well with the total exports from the said regions. As for the economies importing iron ore during 2015, China imported 950 Mt (65% of global exports), Japan 130 Mt (9%), Other Asia 185 Mt (12%) and the EU(28) 150 Mt (10%) making up 1.4 Bt or 95% of total global imports with China being the single biggest importer by far (Worldsteel Association, 2010-2016).

Figure 3.23 provides as summary of the supply and implied demand balance. The supply data is sourced from the USGS data (2006-2016) and based on metal content normalized to a 62% Fe product specification. The implied demand is derived from the apparent steel consumption data from the Worldsteel Association (2010-2016) and steel recycling data from the Bureau of International Recycling (2006-2016). During 2005, the supply and demand was in balance. As from 2006 to 2011, there was a continuous increase in oversupply of iron ore from 10% (2006) to 22% (2011) per year seen to be very significant. The percentage oversupply reduced from 2011 (22%) to 2013 (18%), then increased significantly during 2014 at 27% and 2015 at 26%. The iron ore oversupply, which is seen to be very significant for the period 2014 and 2015, correlates well with the period of collapsed prices.

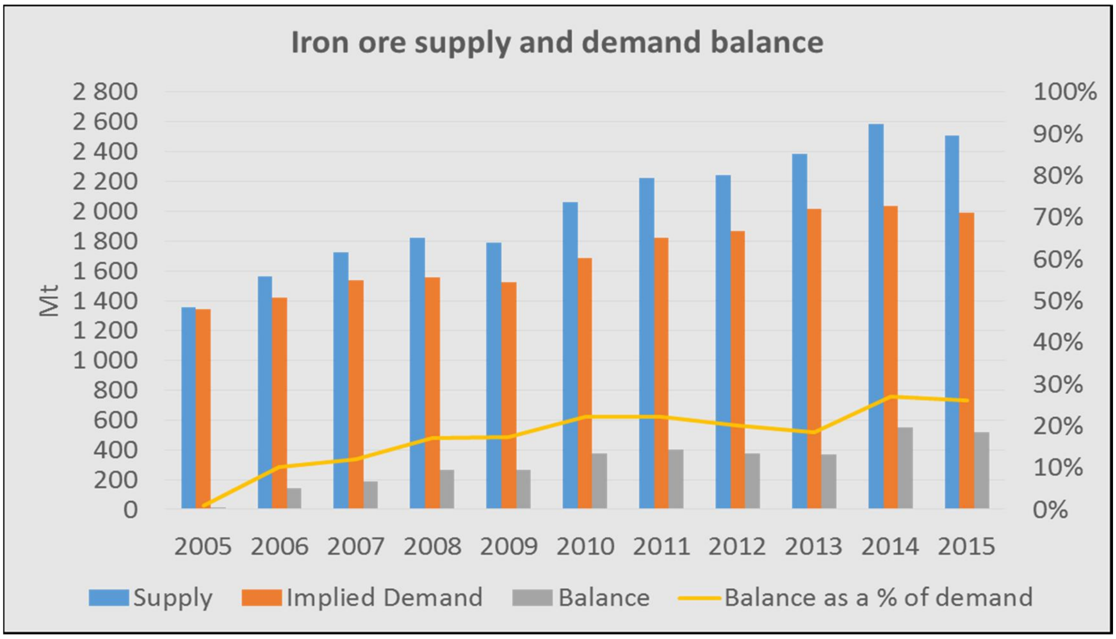

Figure 3.23: Iron ore supply and implied demand balance from 2005 to 2015 (Source data: Worldsteel association (2010-2016), USGS (2016), Bureau of International Recycling (2016))

3.15 Balance of supply and demand vs. iron ore price (2005 – 2015)

It is evident from Figure 3.23 that the market experienced a decade of oversupply in anticipation of continuous growth from China supporting increased demand. It was only when China's demand for steel and iron ore slowed down that the oversupply situation were exaggerated with a resultant collapse in iron ore prices. Figure 3.24 summarizes the supply and implied demand balance over the ten-year period with the China iron ore imports as a key determinant, as well as the price plotted over the said period.

It is clear that the unprecedented demand for iron ore, predominantly from China, grew significantly year on year. This would have presented an opportunity for new entrants to the market and current producers to increase output. Based on the data available, supply exceeded demand increasingly over the period, in particular from 2010 onwards.

Based on the economics of supply and demand, one would expect that there should be some level of correlation between supply, demand and price. It is not that visible when considering Figure 3.24 over the ten-year period. That said, during periods of high prices one would expect supply to increase, which is evident from the graph. Prolonged periods of high prices should place pressure on demand and should result in a reduction in demand of iron ore. From Figure 3.24, one can conclude that the global implied demand did not increase from 2013 onwards. The implied demand for 2014 was flat, when compared to 2013 and indicated a slight reduction in 2015. One can therefor conclude from Figure 3.2 that supply increased during periods of inflated prices and demand decreased over prolonged periods of inflated prices. There is, however, a delayed response of price influencing supply and demand by a number of years.

Iron ore imports to China is a very significant aspect from a demand perspective. Major iron ore projects in China resulted in significant increases in iron ore production. As mentioned earlier in this chapter, the quality of the Chinese iron ore is seen to be very low (often below 30% Fe) and high quality ore is required to blend the ore prior to use. The iron ore imports of China grew substantially to almost 1 Bt per annum for 2015. The implied global demand for iron ore was 2 Bt in 2015 at a 62% Fe and the iron ore import demand from China was 1 Bt for the same year. From Figure 3.18, it is evident that there was a slowdown in iron ore imports during the latter part of 2014 through 2015. This coincides with the significant reduction in iron ore prices.

With iron ore exports averaging 1.5 Bt for 2015, this is a clear indication of the significance of the global seaborne iron ore market. Another important aspect is that a number of Chinese iron ore mines are state owned and as a result may not be directly driven by profit in the short term, but rather meeting government policy and objectives. On that basis, Chinese iron ore mines may react different to price changes when compared to other privately owned mines.

On the basis of global supply and demand, it is clear that there was and is a substantial oversupply of iron ore, when compared to the implied demand. One could thus conclude that the price is predominantly determined and driven by the cost of production that meets the required demand. Major Chinese, high cost supply was introduced to the market over the ten-year period, prompting an increase in production capacities from Australia and Brazil as a result of higher iron ore prices and consequently aggravating the over-supply situation.

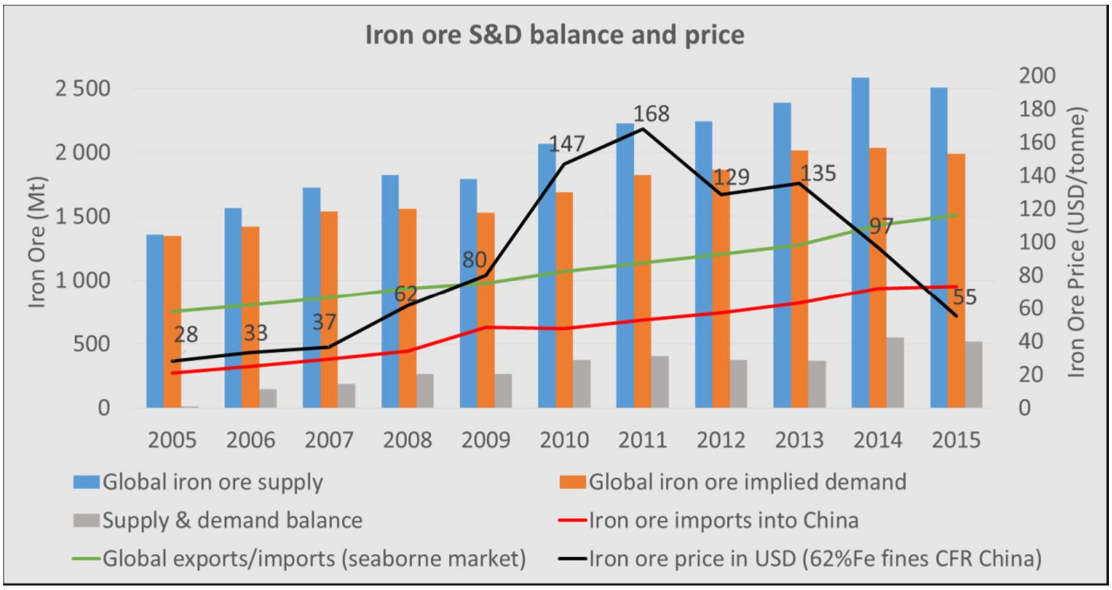

Figure 3.24: Iron ore supply and demand balance with price from 2005 to 2015 (Source data: Worldsteel Association (20010-2016), USGS (2016), Bureau of International Recycling (2016))

From figure 3.24, it is evident that more than adequate supply was available due to the continuous expansion and introduction of additional iron ore to the market. The Australian, Brazilian and Chinese production growth assisted to meet and exceed the demand. As shown in Table 3.4, the Chinese iron ore qualities are significantly lower, when compared to other major iron ore producing countries. This will have an impact on the cost and will be investigated in chapter four as part of the cost curve analysis. The cost curves for the global supply, as well as the global iron ore seaborne trade, will provide some insight into the cost of production and correlation with price. When the prices are low, producers are under pressure to reduce cost leaving unprofitable producers with no option but to close operations.

3.16 Chapter summary

Approximately 98% of global iron ore is utilized for steel making. (Iron Investing News, 2016). During the steel making process, approximately 97% of iron by content is required and other metals make up the balance. Based on data from 2013, 50% to 60% of global steel was used for construction and 20% to 25% for the machinery industry (Mukherji, 2015). This is primarily driven by emerging economies and in particular, the urbanisation and industrialisation drive in China. When comparing steel consumption of developed economies with global consumption, only 36% and 11% of steel is used for construction and machinery, respectively, in developed countries.

Apparent global steel consumption grew by 500 Mt from 1 Bt in 2005 to 1.5 Bt in 2015 at an average annual growth rate of 4% per annum. This substantial increase was primarily driven by China as the steel consumption in China increased by 350 Mt over the period 2005 to 2015. The consumption in China, as a percentage of global consumption, increased from 32% in 2005 to 45% in 2015. A very clear slowdown and reduction in steel consumption is evident from 2013 to 2015 (Worldsteel Association, 2010-2016). Urbanisation in China increased from 40% in 2005 to 55% in 2015 and still have a long way to go, when compared to the USA at 80% and Japan at 90%. Urbanisation for India was only at 30% in 2015 with an annual urbanisation rate of 0.4% at present (The World Bank, 2016).

China’s economy is currently undergoing structural change and moving towards a services economy. The GDP contribution per sector was approximately 10% agriculture, 40% industry and 50% services for 2015. Japan’s contribution per sector was approximately 70% services and 30% industry and as for the USA, 80% services and 20% industry. Another indication that, although China is moving towards a services economy, they still have some way to go (The World Bank, 2016).

China produced 50% of global steel during 2015, up from 31% in 2005. So, not only is China the largest consumer of steel at 45%, but also the largest producer of steel at 50% (Worldsteel Association, 2010-2016). Recycling plays a very important role globally in the supply and demand balance. For developed economies, old steel (also known as scrap steel) is readily available. As for emerging economies the availability of old steel is limited but should increase over time. Recycling of old scrap was 230 Mt to 250 Mt per annum from 2010, accounting for approximately 15% of steel produced (Bureau of International Recycling, 2016).

With China as the largest producer of steel with little recycling at present, it is globally the largest consumer of iron ore. The imports of iron ore increased by 700 Mt over the ten-year period from 250 Mt in 2005 to 950 Mt in 2015, primarily sourced from Australia and Brazil. Global iron ore production increased from 1.5 Bt in 2005 to 3.3 Bt in 2015 and China, Brazil and Australia makes up 80% of global supply. Normalized to a 62% Fe product specification, iron ore output increased from 1.4 Bt in 2005 to 2.5 Bt in 2015 (USGS, 2016).

Iron ore production from China is of very low quality, typically below 30% Fe and as a result does not contribute equally to other producers from a metal content perspective. The four largest producers, Vale, RIO, BHP and FMG, collectively increased output by 550 Mt from 450 Mt in 2005 to 1 Bt in 2015.

There appears to have been a significant oversupply of iron ore, in particular from 2010 onwards. Global supply grew faster than global demand. Global imports/exports grew steadily over the ten-year period, as did the iron ore imports into China. The correlation between either supply or demand and price is not that clear. Based on the data, one can however conclude that supply increased during periods of high prices and demand reduced over prolonged periods of high prices. There does however, appear to be a significant delayed response between supply, demand and price.

As discussed previously, the four large producers dominate the iron ore market. Chapter four will focus in detail on the analysis of their financial performance and will provide some insight into the profitability at recent prices and their sustainability. Chapter 4 will also analyse cost curves to correlate price movements with supply and demand.

4 PROFITABILITY AND SUSTAINABILITY (IRON ORE PRICE AND COST CURVE ANALYSIS)

4.1 Chapter overview

Chapter 4 provides an analysis of the four largest global iron ore producers' annual financial results. The four largest global producers form the backbone of the iron ore industry and understanding their financial position as well as profitability, will provide some insight into their cost of production price support levels. The analysis focused on total tonnes produced per annum, realised iron ore price, profit margins, capital spend, and earnings before interest, tax, depreciation and amortization (EBITDA) margin, as well as debt to equity ratios.

4.2 Challenges when analysing financial statements

There are various challenges when annual financial statements are analysed for the industry to compare various businesses for profitability and business continuity. These challenges have various impacts and must be understood to make a representative comparison and draw conclusions.

From an iron ore perspective, the pricing system is based on various parameters and the key parameter is linked to iron ore content, as well as fines or lump product which change continuously. The second significant parameter impacting price is the point of sale which generally is either free on board (FOB) or CFR. FOB is the total cost of production including the cost of rail and port charges to place the iron ore onto a ship. CFR includes freight and insurance and is the total cost delivered to the destination. The majority of the financial statements do not provide any detail on the product specification or the point of sale and purely refer to the realised iron ore price. On that basis, it is very difficult to compare the cost of production since the quality specification, premiums, discounts and contaminants are not explicitly stated nor is the point of sale. Because of this, the operating profit margin is seen to provide a better indication of the actual impact of the realised price and cost.

Another challenge is that the financial year-end differ presenting some challenges for direct comparison. This will somewhat skew the analysis, however, it is not seen to be significant for this analysis since the average realized price will be shown per period and producer for comparison purposes. BHP and FMG's financial year-end is 30 June and RIO and Vale is 31 Dec.

Stay in business (SIB) capital, is typically capital that is required for business continuity. The annual financial statements of the various businesses do not separate SIB and expansionary capital making it very difficult to isolate SIB capital. To have a good understanding of the comparative cost and true profit margins, stay in business capital intensity stated as USD/tonne should be considered. When included in the cost, the cost is referred to as a total cash cost per product tonne. For this particular research project, SIB will not be considered and is not seen to be significant for the purpose of the study. The macro-economic environment is fundamental when considering company financials and will be discussed in some detail.

4.3 Macro-economic setting

As discussed in previous chapters, China experienced a slowdown in economic activity, which had a perceived impact on the demand for growth commodities in particular. This had an impact on commodity prices and because of a materially over-supplied iron ore market, this exaggerated the situation. Mining companies reduced their price forecasts and outlook on future earnings as did the analysts. Major impairments were incurred on the back of the expected lower commodity prices. Mining companies were placed and still are under severe pressure to reduce debt levels and operating cost. When commodity prices collapsed in 2015, the equity for mining companies reduced significantly since the value of the companies was significantly influenced with lower prices, which worsened the debt to equity ratio. There was an industry wide concern that mining companies may not be able to service their debt because of the low price environment. Because of that, there was a massive focus placed on companies to reduce their debt levels to acceptable levels.

Oil prices also reduced significantly over the period and resulted in lower mining and transportation cost. Figure 4.1 provides an overview of the global oil prices in USD/barrel. Prior to the collapse of the iron ore prices, brent crude was trading in a range between 100 and 120 USD and reduced to an average of around USD 50/barrel. The majority of the iron ore mines are open pit operations with truck and shovel operations consuming large amounts of fuel. Some of the Brazilian mines have in pit crushing and conveying systems and are not as dependant on fuel as an input cost (Infomine, 2016). This is currently the exception and not the norm on a global scale. When considering the exchange rates for the two large producing countries, namely Australia and Brazil, the oil price in local currency reduced by approximately 50% for Australia and 30% for Brazil. According to data form Infomine (2014), the diesel cost accounts for approximately 30% of mining cost. Therefore, as an example for a cost of production of approximately USD25-30, the reduction in oil price would yield a saving of approximately USD 5/tonne. In other words, an oil price reduction of 50% resulted in an operating cost reduction of approximately 15%.

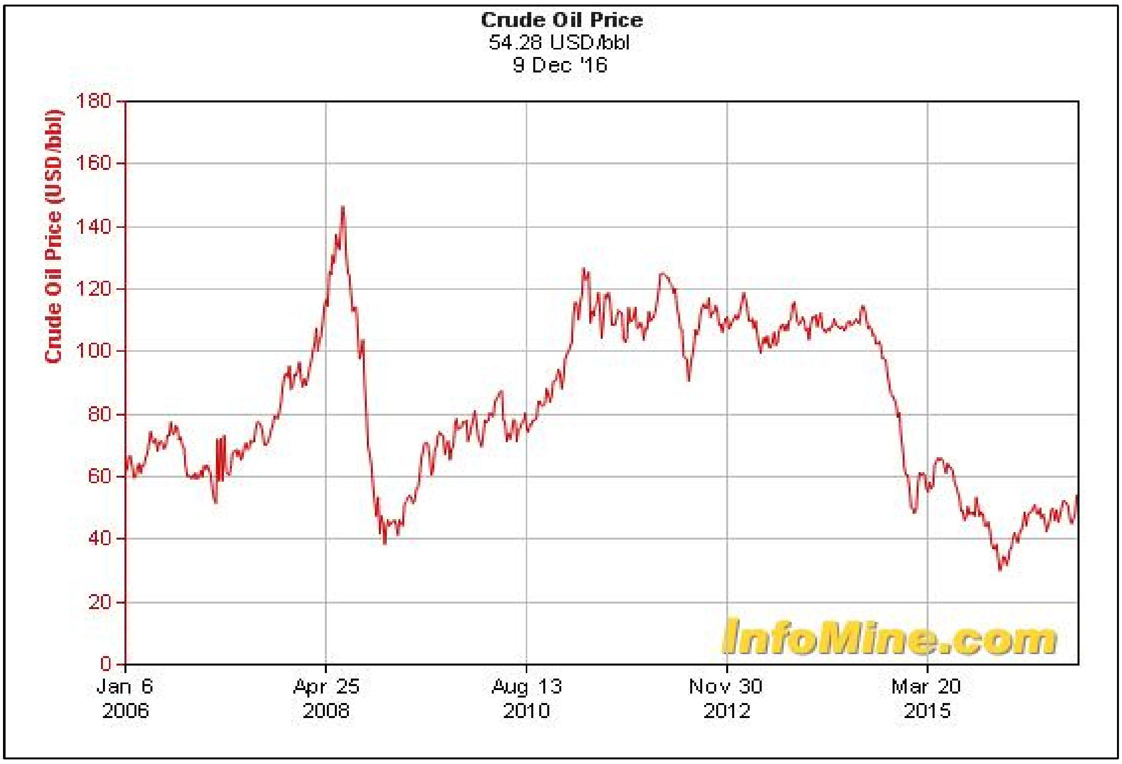

Figure 4.1: Global oil price from 2006 to 2016 (Infomine, 2016)

Another important aspect is the cost of freight from Australia and Brazil to China. The point of transaction may skew the impact on cost, however, the impact on operating profit margin will remain. As indicated in Figure 4.1, oil prices effectively halved from 2014 levels to 2015. This also positively effected the cost of freight for producers (Infomine, 2016). According to the Sydney Morning Herald (2015), the Baltic dry index fell mainly because of the oversupply of ship capacity, as well as the impact of reducing oil prices, reducing the shipping cost from Australia to China from USD10/tonne in 2014 to USD5/tonne during 2015. As for Brazil, the cost was USD 20/tonne and reduced to USD10/tonne. A cost reduction from 2014 to 2015 to the order of USD10/tonne for Australia and USD15/tonne for Brazil, on a CFR China basis, can therefore be explained due to a combination of the reduced global oil prices and Baltic freight rates.

4.4 Financial analysis - BHP

Table 4.1 provides an overview of the five-year financial performance for BHP's global iron ore business. The production increased significantly over the five-year period from 159 Mt in 2012 to 226 Mt in 2016. Over the same period, the realised iron ore price reduced from USD 133 to USD 44 per tonne. Because of the significant reduction in iron ore prices, the EBITDA reduced from USD 15 billion to USD 5.6 billion (BHP Billiton, 2012, 2014, 2016).

The global iron ore business contributed significantly to the overall business at 45% of total EBITDA in 2016. BHP maintained the EBITDA margin during a prolonged period of falling commodity prices. The EBITDA margin only reduced by 13% from 66% to 53%, whilst the iron ore prices reduced by approximately 67%. BHP achieved this through a continued focus on cost reduction as is summarized in Figure 4.2. Capital spent was reduced to manage debt levels and the debt to equity ratio between the 0.3 to 0.6 range. Major expansionary projects, namely Jimblebar, and the broader debottlenecking of the supply chain also came to an end supporting the reduction in capital spent. EBITDA as a percentage of group EBITDA is shown to highlight the significance of the iron ore contribution (BHP Billiton, 2012, 2014, 2016).

Table 4.1: BHP financial analysis (2012 to 2016)[5]

	2012	2013	2014	2015	2016
Iron ore production (BHP Share) Mt	159	170	203	232	226
Iron ore price realized (US$/tonne)	133	110	103	61	44
Iron ore Capital spend (US$ B)	5.6	5.9	2.9	2.0	1.1
Iron ore Capital spend (US$/tonne)	35	35	14	9	5
Iron ore revenue (US$ B)	22.6	18.6	21.4	14.7	10.5
Iron ore Underlying EBITDA (US$ B)	15	12.1	13.5	8.6	5.6
Iron ore EBITDA margin (%)	66%	65%	63%	59%	53%
Iron ore EBITDA as a % of company EBITDA	45%	40%	44%	40%	45%
Group profit/loss after tax (US$ B)	17.2	12.2	13.5	1.9	-6.3
Company Net debt (US$ B)	22.2	27.5	25.8	24.4	26.1
Equity (US$ B)	65.5	70.6	79.1	64.8	54.3
Debt:Equity	0.3	0.4	0.3	0.4	0.5

Figure 4.2 demonstrates that BHP managed to reduce its operating cost per tonne over the five-year period. The reduction in unit operating cost over the period is primarily driven by lower global oil prices, excess shipping capacity, economies of scale and efficiency improvement drives.

[5]Source data: BHP Billiton (2012), BHP Billiton (2014), BHP Billiton (2016)

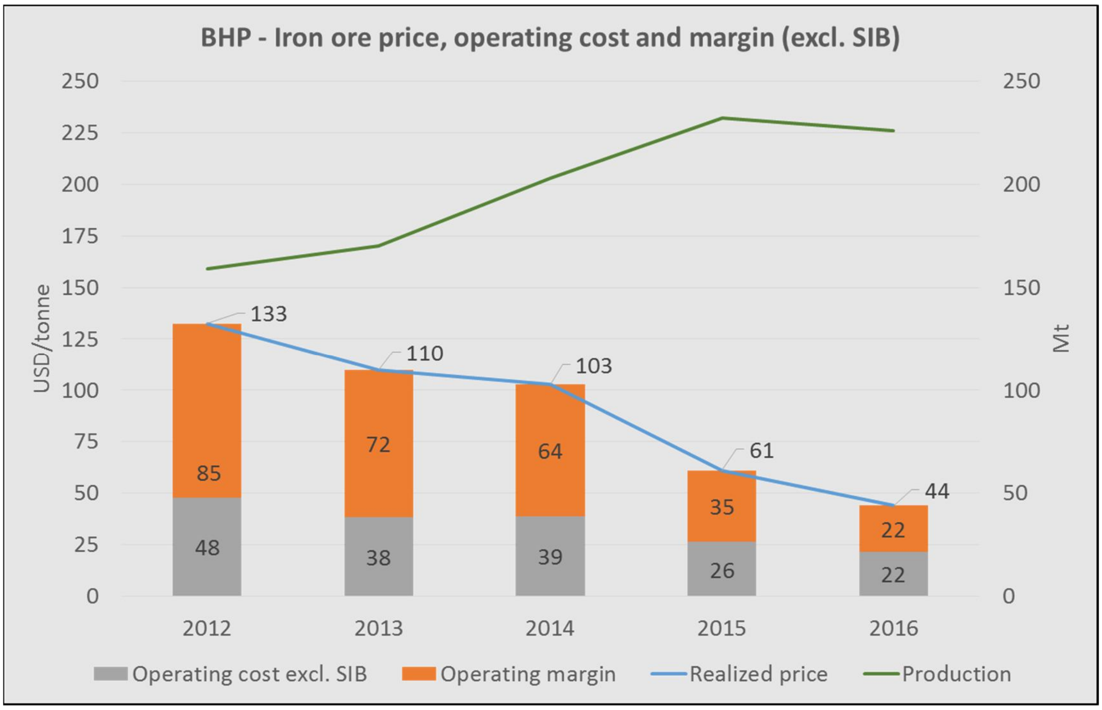

Figure 4.2: BHP production, price and cost (2012 to 2016)[6]

4.5 Financial analysis - RIO

Table 4.2 provides an overview of the financial results for the previous five-year period. Production increased from 191 Mt in 2011 to 263 Mt in 2015. Over the same period, the realized iron ore price per tonne reduced by 63% from USD154 to USD58, resulting in revenue nearly halving from approximately USD29.5 billion to USD15.3 billion. Underlying EBITDA reduced by USD13.4 billion over the said period. Iron ore played a significant role in the overall business and contributed approximately 70% of total company EBITDA. The EBITDA margin reduced from 72% to 52% and similar to BHP, the EBITDA remained reasonably high due to continued cost reductions. RIO reduced their debt from a maximum of USD19.2 billion in 2012 to USD13.8 billion in 2015. The capital spent also reduced due to some major capital expansionary projects being delivered (Rio Tinto, 2012, 2014, 2016).

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[6]Source data: BHP Billiton (2012), BHP Billiton (2014), BHP Billiton (2016)

Table 4.2: RIO financial analysis (2011 to 2015)[7]

	2011	2012	2013	2014	2015
Iron ore production (RIO Share) Mt	191	198	208	233	263
Realized iron ore price estimate (US$/tonne)	154	123	125	100	58
Iron ore Capital spend (US$ B)	4.0	7.1	6.8	4.2	1.7
Iron ore Capital spend (US$/tonne)	21	36	33	18	6
Iron ore revenue (US$ B)	29.5	24.3	25.9	23.3	15.3
Iron ore Underlying EBITDA (US$ B)	21.3	15.7	17.4	14.2	7.9
Iron ore EBITDA margin (%)	72%	65%	67%	61%	52%
Iron ore EBITDA as a % of company EBITDA	72%	77%	77%	72%	63%
Group profit/loss after tax (US$ B)	5.8	-3.0	3.6	6.5	-0.9
Company Net debt (US$ B)	8.3	19.2	18	12.5	13.8
Equity (US$ B)	52.2	46.5	45.9	46.3	37.3
Debt:Equity	0.2	0.4	0.4	0.3	0.4

Figure 4.3 summarises the realised price, operatingcost and margin. RIO's operating cost per tonne reduced from USD43 in 2011 to USD28 in 2015. The reduction in unit operating cost from 2011 to 2014 was primarily driven by scale of economies and was negligible. The large reduction occurred over the period 2014 to 2015 to the order of USD 11/tonne. Economies of scale had some impact due to the increase in annual output, however, the primary reason for the reduction was the reduction in oil price (Rio Tinto, 2012, 2014, 2016).

[7]Source data: Rio Tinto (2012), Rio Tinto (2014), Rio Tinto (2016)

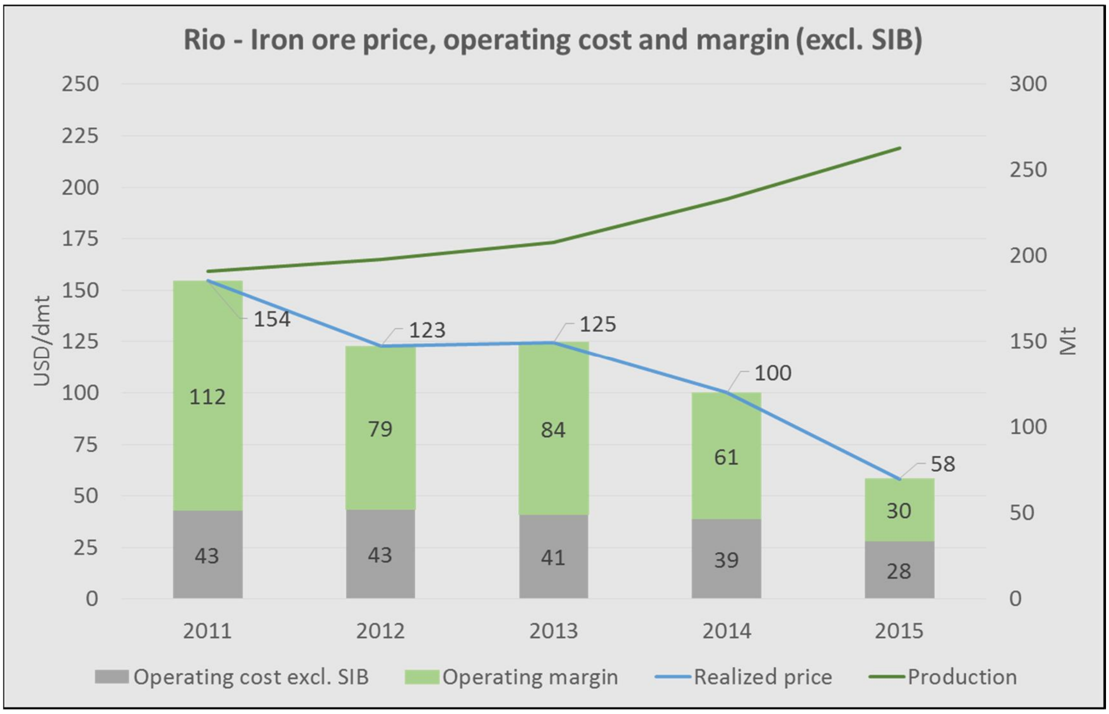

Figure 4.3: Rio production, price and cost (2011 to 2015)[8]

4.6 Financial analysis – Vale

As summarized in Table 4.3, the annual production output from Vale increased by approximately 7% over the five-year period and was significantly lower than some of the other major competitors. The revenue was reduced by approximately 67% as iron ore prices decreased by approximately 70% over the said period. Underlying EBITDA reduced significantly by USD21.3 billion from USD25.4 billion to USD4.1 billion. Group EBITDA contribution reduced from 74% in 2011 to 58% in 2015. EBITDA as a percentage of group EBITDA were calculated as iron ore EBITDA divided by group EBITDA. The annual capital spent remained reasonably flat over the period and was significantly lower than that of other large competitors. A major contributor is the fact that Vale did not undergo major expansionary projects over the said period. Because of this, the annual capital spend provides a fair indication of the annual SIB capital spent. The debt to equity ratio for 2015 was high at 0.7,

[8]Source data: Rio Tinto (2012), Rio Tinto (2014), Rio Tinto (2016)

when compared to the competitors. This is mainly due to the equity reducing drastically for 2015 (Vale, 2011, 2013, 2015).

Table 4.3: Vale financial analysis (2011 to 2015)[9]

	2011	2012	2013	2014	2015
Iron ore production (Vale Share) Mt	322	320	310	332	346
Iron ore price realized (US$/tonne)	143	105	112	75	44
Iron ore Capital spend (US$ B)	0.4	0.4	0.4	0.6	0.4
Iron ore Capital spend (US$/tonne)	1	1	1	2	1
Iron ore revenue (US$ B)	36.9	27.2	27.8	19.3	12.3
Iron ore Underlying EBITDA (US$ B)	25.4	13.9	17.1	8.1	4.1
Iron ore EBITDA margin (%)	69%	51%	62%	42%	33%
Iron ore EBITDA as a % of company EBITDA	74%	79%	75%	61%	58%
Group profit/loss after tax (US$ B)	22.6	5.3	0.4	0.3	-12.6
Company Net debt (US$ B)	19.6	24.4	24.3	24.6	25.2
Equity (US$ B)	77.8	74.8	64.9	56.3	35.7
Debt:Equity	0.3	0.3	0.4	0.4	0.7

Vale has managed to reduce the annual operating cost with a very limited contribution from increased output and scale of economies as is indicated in Figure 4.4. As with the other majors, the operating margin reduced significantly because of the reduction in realized iron ore price. The big step-change in cost reduction per tonne as with the other majors occurred from 2014 to 2015 to the extent of USD10. This primarily relates to lower oil prices as with the other major producers (Vale, 2011, 2013, 2015).

[9]Source data: Vale (2011), Vale (2013), Vale(2015)

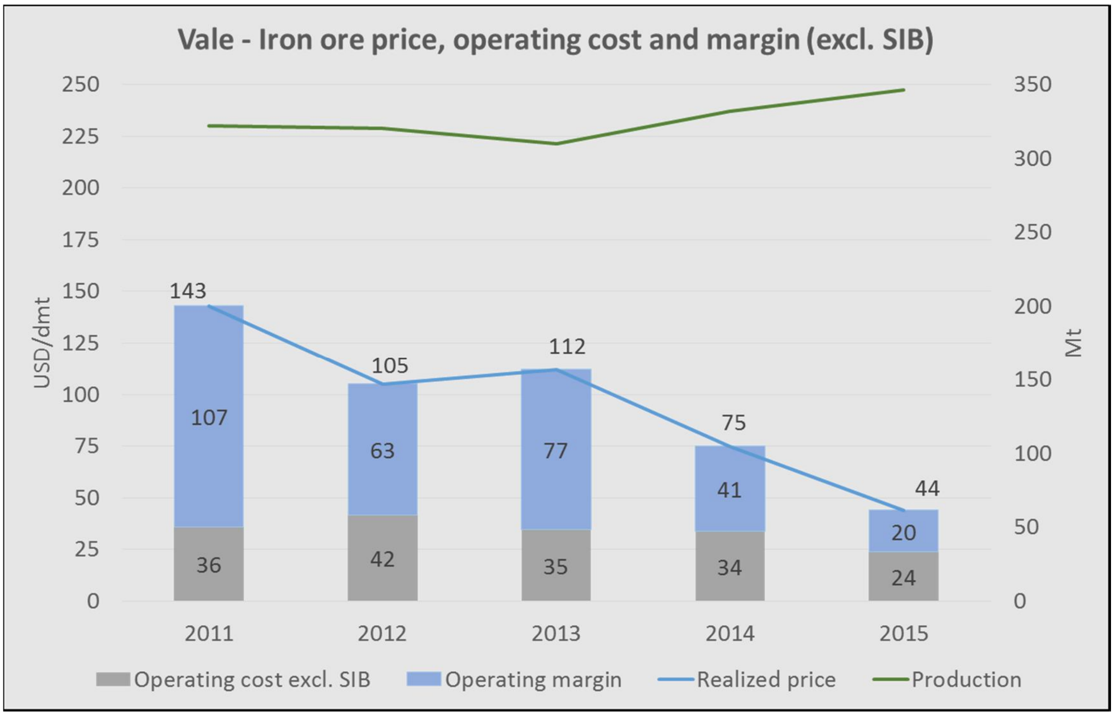

Figure 4.4: Vale production, price and cost (2011 to 2015)[10]

4.7 Financial analysis – FMG

FMG being a newly established company underwent a significant expansionary phase and annual output increased from 58 Mt in 2012 to 169 Mt in 2016. Due to the production ramp-up, the revenue remained relatively stable in a falling iron ore price environment over the period in question as per Table 4.4. FMG's is a company with only iron ore assets and as such, the overall company financial performance reflects the iron ore business. The EBITDA margin was 45% in 2012 and 45% in 2016. The capital spent reduced over the period as the ramp up neared steady state production with the conclusion of some of the large capital expansionary projects namely Chichester Hub and Solomon Hub (FMG, 2012, 2014, 2016).

During 2012, the annual capital spend was USD6 billion and reduced to USD0.3 billion in 2016. The annual capital of approximately USD2 per tonne provides an indication of SIB capital. The SIB will in all likelihood increase as the operations and equipment ages. FMG's company's nett debt peaked at

[10]Source data: Vale (2011), Vale (2013), Vale(2015)

USD10.5 billion in 2013 and reduced to USD5.2 billion in 2016. The company profit after tax was USD1 billion for the 2016 reporting year (FMG, 2012, 2014, 2016).

Table 4.4: FMG financial analysis (2012 to 2016)[11]

	2012	2013	2014	2015	2016
Iron ore production (FMG Share) Mt wet basis	58	81	124	165	169
Iron ore price realised CFR China (US$/DMT)	131	114	106	57	45
Iron ore Capital spend (US$ B)	6.0	6.3	1.9	0.6	0.3
Iron ore Capital spend (US$/tonne)	104	78	15	4	2
Iron ore revenue (US$ B)	6.7	8.1	11.8	8.6	7.1
Iron ore Underlying EBITDA (US$ B)	3.0	3.6	5.6	2.5	3.2
Iron ore EBITDA margin (%)	45%	44%	47%	29%	45%
Iron ore EBITDA as a % of company EBITDA	100%	100%	100%	100%	100%
Group profit/loss after tax (US$ B)	1.6	1.7	2.7	0.3	1.0
Company Net debt (US$ B)	6.2	10.5	7.2	7.2	5.2
Equity (US$ B)	3.8	5.4	7.6	7.5	8.4
Debt:Equity	1.6	1.9	0.9	1.0	0.6

The reduction in operating cost in Figure 4.5 is primarily driven by lower global oil prices, excess shipping capacity, economies of scale and efficiency improvement drives. For the 2016 financial year, the operating cost per tonne was approximately USD23 with an operating margin per tonne of approximately USD22 (FMG, 2012, 2014, 2016).

[11] Source data: FMG (2012), FMG (2014), FMG (2016)

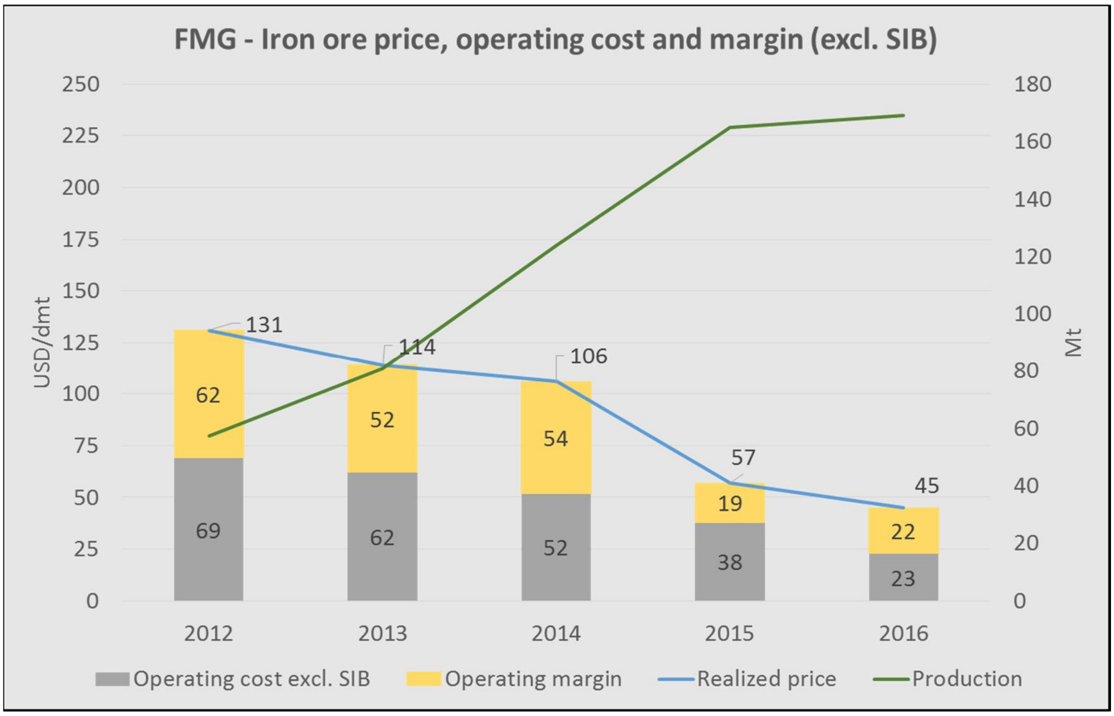

Figure 4.5: FMG production, price and cost (2012 to 2016)[12]

4.8 Financial analysis comparison

Due to the complexity of various reporting periods, two separate company comparisons are shown to demonstrate the operating margin. The realised iron ore prices were used to derive the implied operating margin per company. Various iron ore prices were realised per company because of various reporting periods, different product specifications and point of transaction. For comparative purposes, the benchmark IODEX iron ore fines 62% Fe ($/DMT) CFR China iron ore prices were used in the analysis. Figure 4.6 and 4.7 provides a summary of the operating margin per company excluding SIB over the five-year period when compared to the benchmark price.

Figure 4.6 provides an operating margin comparison for BHP and FMG as their reporting periods are the same. Both companies had an operating profit margin per tonne of approximately USD22 for the period of 2016 with a benchmark iron ore price per tonne of USD51. One could safely conclude that

[12]Source data: FMG (2012), FMG (2014), FMG (2016)

both these companies, even with the inclusion of SIB, have a reasonable margin at low iron ore prices.

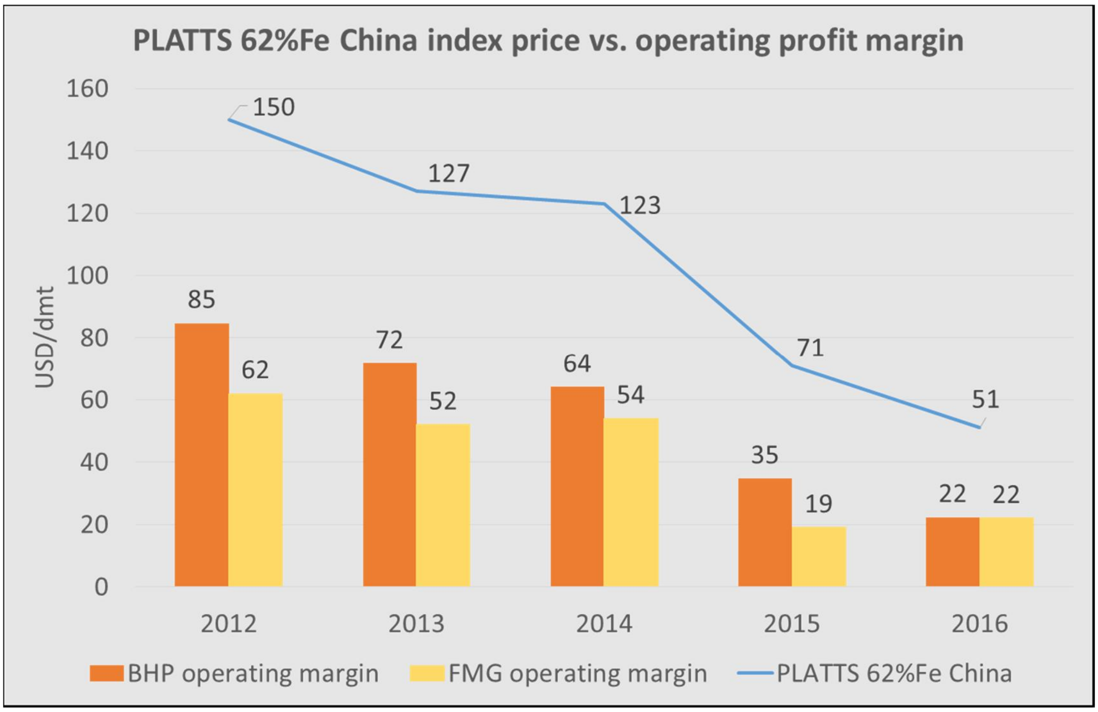

Figure 4.6: BHP and FMG margin comparison (2012 to 2016)[13]

Figure 4.7 provides an operating margin comparison for RIO and Vale, as their reporting periods are the same. It is understood that the profit margins reduced significantly over the period because of reducing iron ore prices. For the 2015 period, Vale realised and operating profit margin per tonne of approximately USD20 and RIO USD30 with a benchmark iron ore price per tonne of USD50. Vale increased output by approximately 7% and Rio by 37% over the study period. Vale remains much larger than RIO from an annual output perspective. RIO was the producer with the highest operating margin per tonne of the four majors for 2016.

[13] Source data: BHP Billiton (2012), BHP Billiton (2014), BHP Billiton (2016), FMG (2012), FMG (2014), FMG (2016)

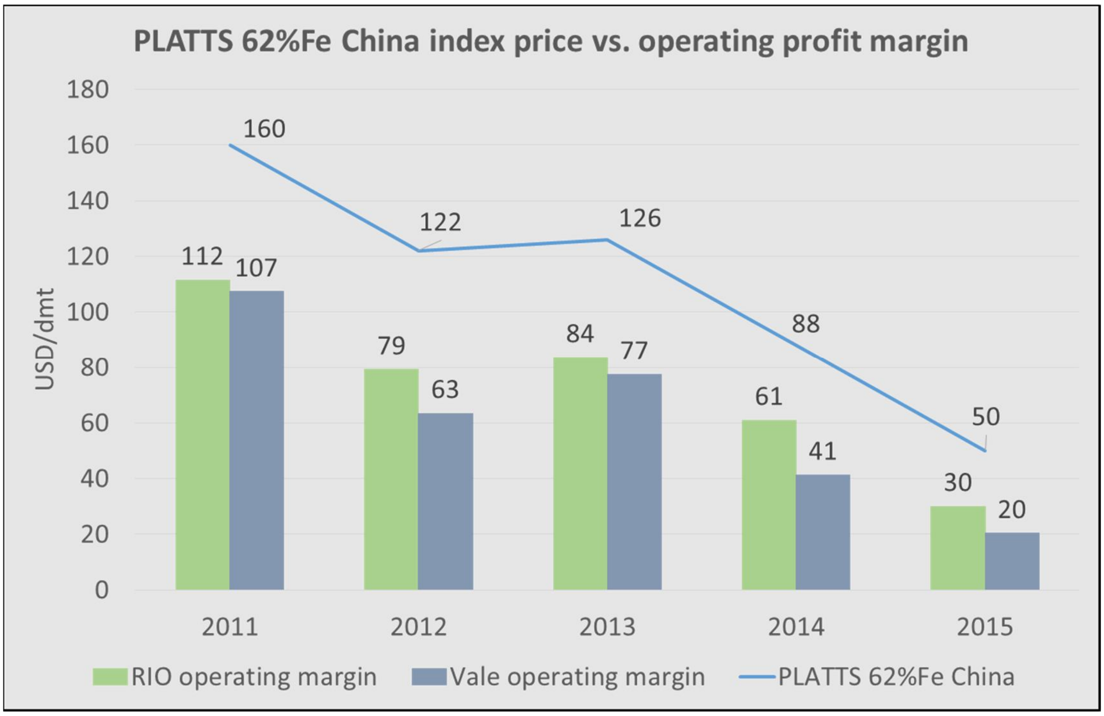

Figure 4.7: Rio and Vale margin comparison (2011 to 2015)[14]

Figure 4.8 provides an overview of the EBITDA margin per major producer and is a good metric for profitability. With the exception of FMG due to production ramp-up, the EBITDA margin was above 65% for the three majors in 2012. Itis reduced over the five-year period, mainly because of falling commodity prices to approximately 50%, with Vale being the outlier at 33%.

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[14]Source data: Rio Tinto (2012), Rio Tinto (2014), Rio Tinto (2016), Vale (2011), Vale (2013), Vale(2015)

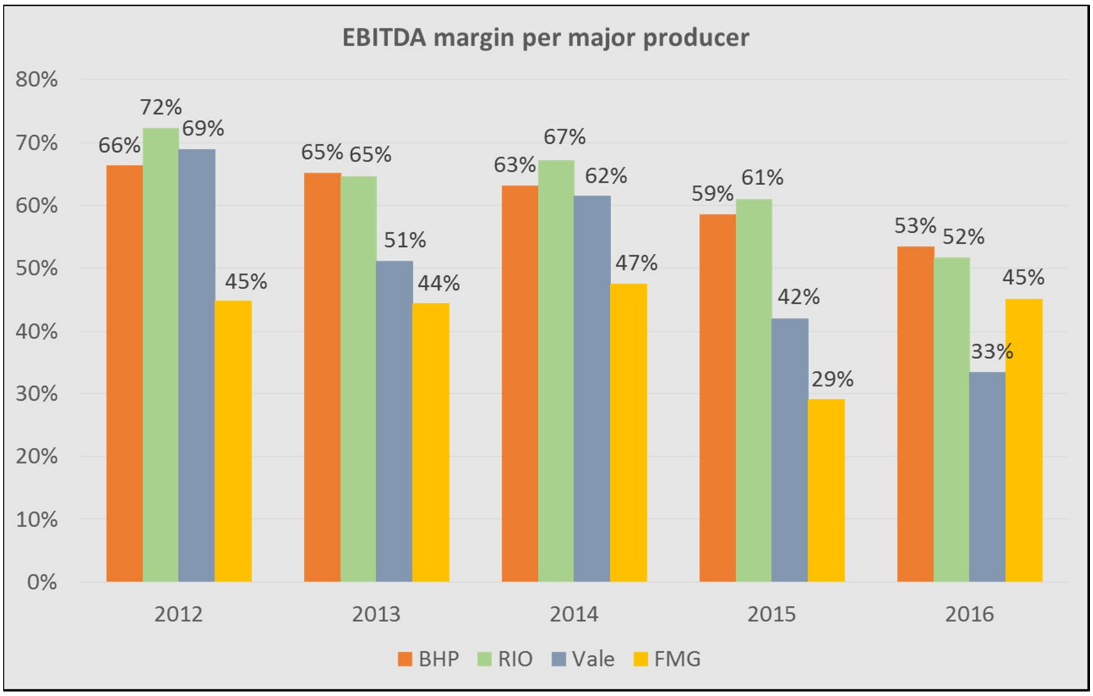

Figure 4.8: EBITDA margin comparison (2012 to 2016)[15]

Figure 4.9 provides an overview of the major producer company's debt position in terms of net debt, as well as debt to equity ratio. All four majors went through a period when the debt spiked in 2013. The debt to equity ratio for BHP, RIO and Vale increased over the five-year period.

As mentioned before, BHP and FMG report mid-year and Rio and Vale end of year. So the numbers are not directly comparable and should only be used for guidance. For 2016, BHP and RIO were best placed from a debt to equity ratio at 0.5 and 0.4 respectively, when compared to Vale at 0.7 and FMG at 0.6.

[15]Source data: BHP Billiton (2012), BHP Billiton (2014), BHP Billiton (2016), FMG (2012), FMG (2014), FMG (2016), Rio Tinto (2012), Rio Tinto (2014), Rio Tinto (2016), Vale (2011), Vale (2013), Vale(2015)

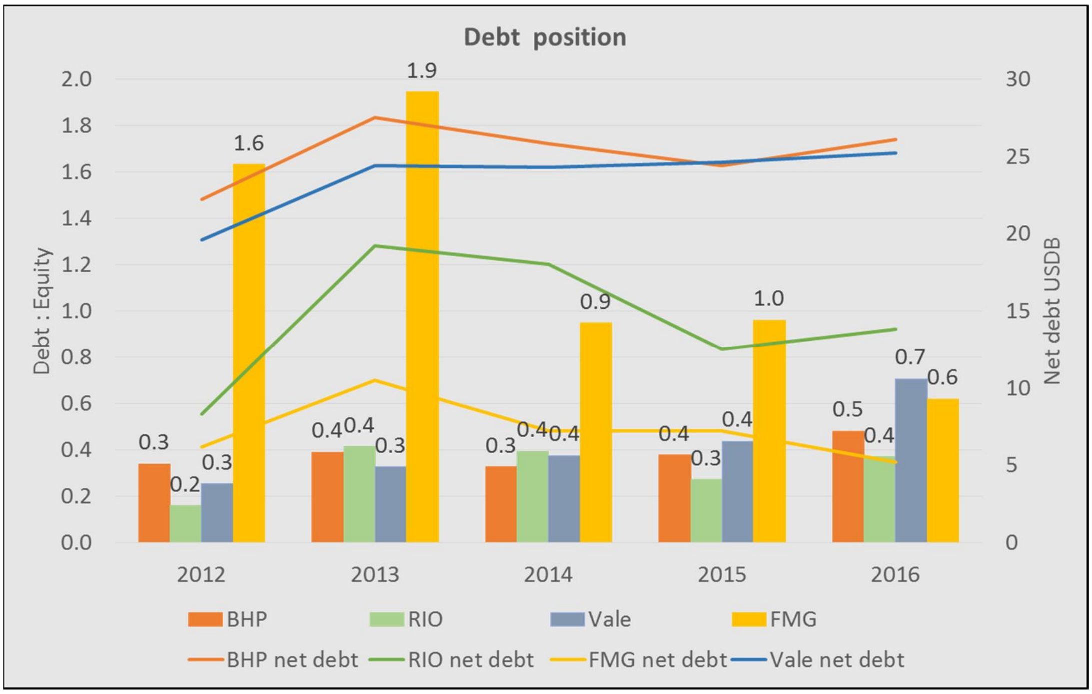

Figure 4.9: Company debt position (2012 to 2016)[16]

4.9 Industry cost curve analysis

Figure 4.10 shows the global iron ore cost curve. The graph is stated on an FOB wet basis and essentially excludes freight. It also excludes Chinese production. So one can essentially compare the graph with the total iron ore exports and imports. From 2005 to 2012, the cost curve essentially extended with higher cost iron ore making it to the market. For 2005, the total global imports and exports were approximately 750 Mtpa according to Worldsteel Association (2010-2016) at an operating cost of approximately USD55 per tonne. By 2012, the total global imports and exports were approximately 1.2 Bt according to Worldsteel Association (2010-2016) at an operating cost per tonne of approximately USD100. By 2015, the total global imports and exports were approximately 1.5 Bt according to Worldsteel Association (2010-2016) at an operating cost per tonne of approximately USD60.

[16]Source data: BHP Billiton (2012), BHP Billiton (2014), BHP Billiton (2016), FMG (2012), FMG (2014), FMG (2016), Rio Tinto (2012), Rio Tinto (2014), Rio Tinto (2016), Vale (2011), Vale (2013), Vale(2015)

From 2005, the iron ore cost curve experienced a shift towards the right meaning that additional supply entered the market. From 2012/2013, the cost curve experienced a downward shift meaning that for the same supply tonnes, the cost of production was lower compared to previous years. Two significant downward moves were experienced over the ten-year period, the first from 2013 to 2014 and the second from 2014 to 2015. These periods coincided with the introduction of low cost tonnes from the larger producers as well as the reduction in oil price as previously explained. By 2015, 800 Mt of iron ore was supplied at a cost per tonne of approximately USD25 to USD30 compared to USD55 to USD60 in 2005. As discussed in Chapter 3, there was a steady increase in global iron ore supply over the last decade. The significant reduction in oil price from 2014 to 2015 had a significant impact on reducing the cost and shifting the curve downwards. Efficiency improvement drives also supported the overall cost reduction.

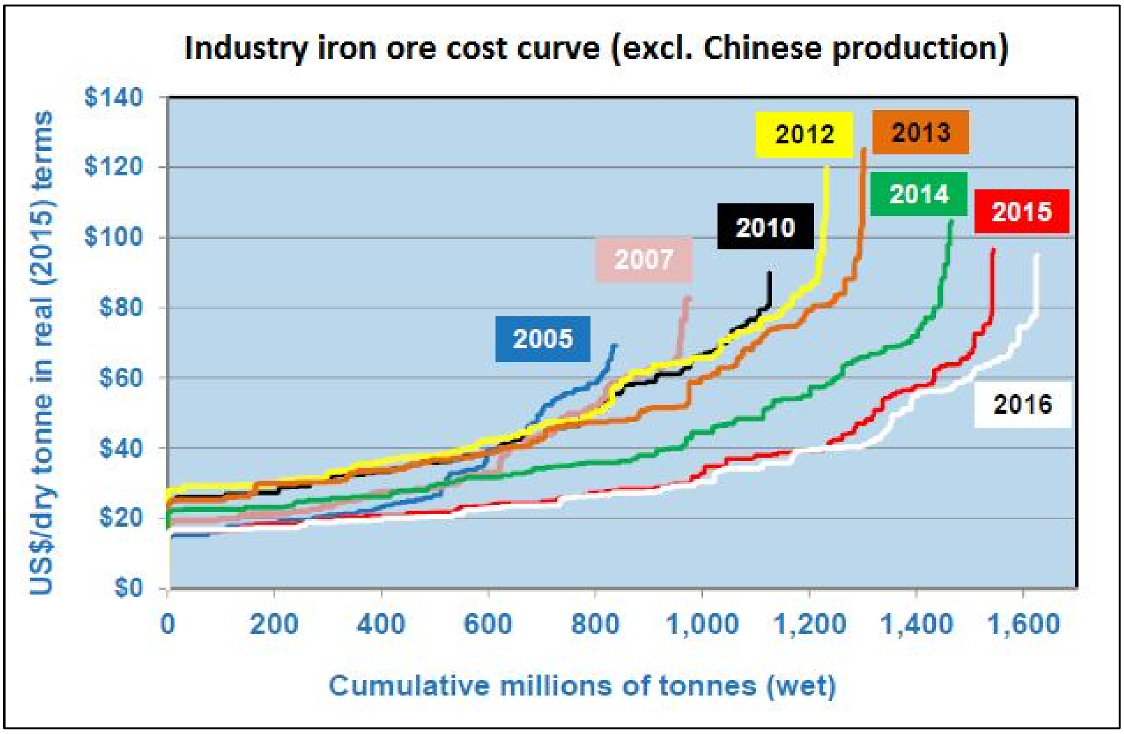

Figure 4.10: FOB cash cost outline excluding China (Barkas, 2015)

Figure 4.11 and 4.12 provides insight into the global iron ore cost curve. Figure 4.11 shows the iron ore supply to China only for 2015 consisting of approximately 950 Mt of iron ore imports and the balance form domestic supply. Figure 4.11 also provides a summary of the 2015 global iron ore cost curve. RIO was the lowest cost producer in 2015 at just below USD30 per tonne, closely followed by BHP at approximately USD30 per tonne. From the major producers, FMG was in third place at slightly above USD30 per tonne, with Vale in fourth place also slightly higher than USD30 per tonne. These costs will vary from the costs derived from the financial statements since the costs stated in figure 4.11 includes freight to China and is normalised for product specification (Metalytics, 2015).

Based on Figure 4.11 the highest cost producers are Chinese producers with the majority producing at above USD70 per tonne for 2015 (Metalytics, 2015). A number of the high cost Chinese operations are state owned and as a result, does not necessarily conform 100% with the supply and demand rules of economics. Often state owned entities have objectives other than profitability, relating to employment, securing supply, etc. Due to this, one cannot safely assume that a loss making operation will be shut down. If one considers China as the single biggest importer of iron ore at approximately 950 Mt for 2015, Figure 4.11 suggests that the demand was met at an average cost of supply of approximately USD55 per tonne. For the year of 2015, the entire Asia only exported 31 Mt. So, one can safely assume that China does not export significant amounts of iron ore. Extra regional imports and exports were 1.4 Bt for 2015 (Worldsteel Association, 2010-2016).

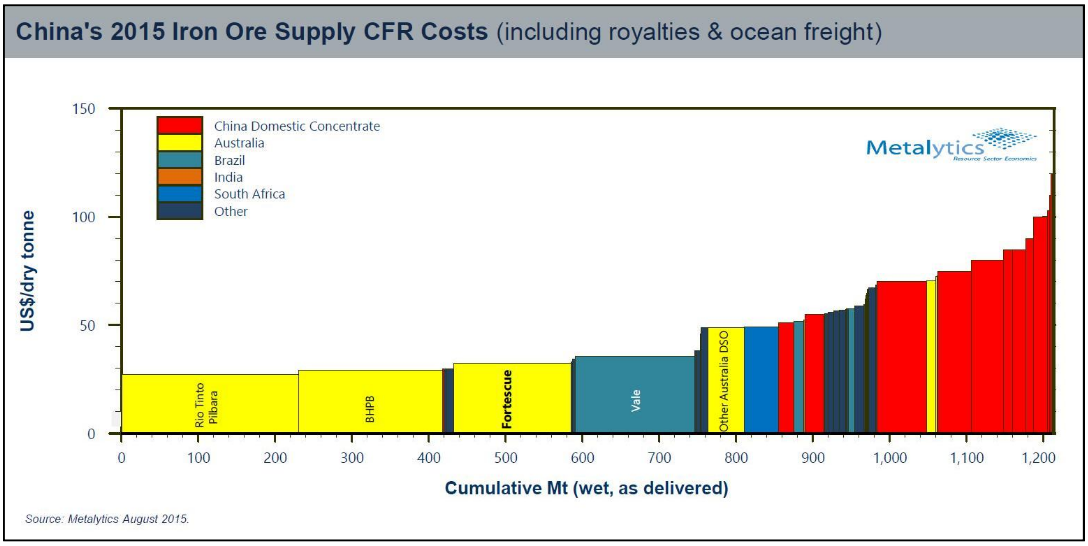

Figure 4.11: China’s iron ore cost curve 62%Fe CFR (Metalytics, 2015)

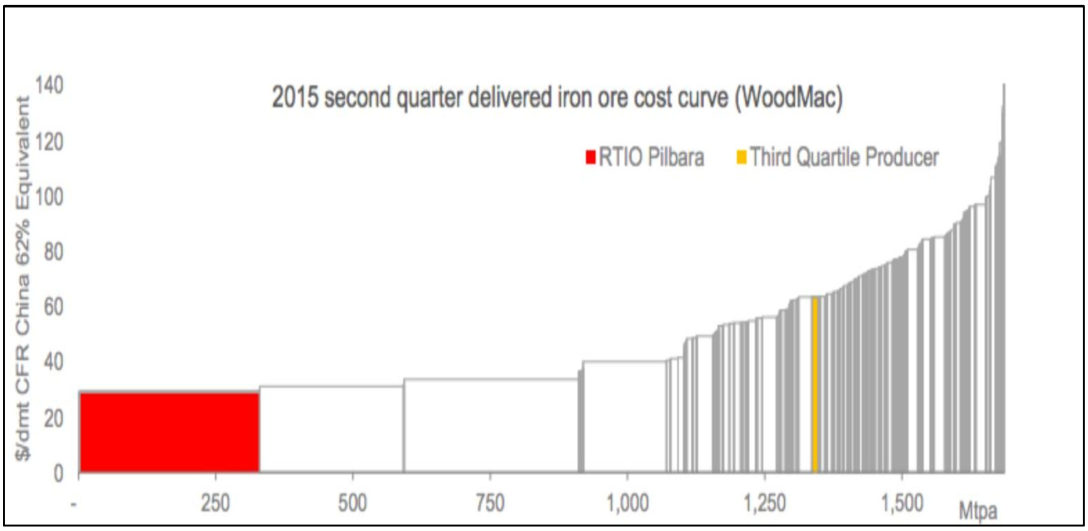

Figure 4.12: Iron ore cost curve 62%Fe CFR (Business Insider Australia, 2016)

Figure 4.13 provides and overview of the global iron ore imports over the period 2005 to 2015. When plotting the demand line from Figure 4.13 for a particular point in time on the global industry cost curves as shown in Figure 4.10, 4.11 and 4.12, one will derive the point at which supply will meet demand and the cost of production. For 2015, with the global iron ore inports at just over 1.4 Bt, the derived iron ore price from Figure 4.12 was approximately USD60 – USD70 per tonne and correlates well as the point at which the market was in equilibrium. It is important to recognise that the cost of production can meet the demand at the said price, assuming oil prices at that point in time which was approximately USD50 per barrel (Infomine, 2016). An increase in oil price will impact the cost of produciton as well as profitability.

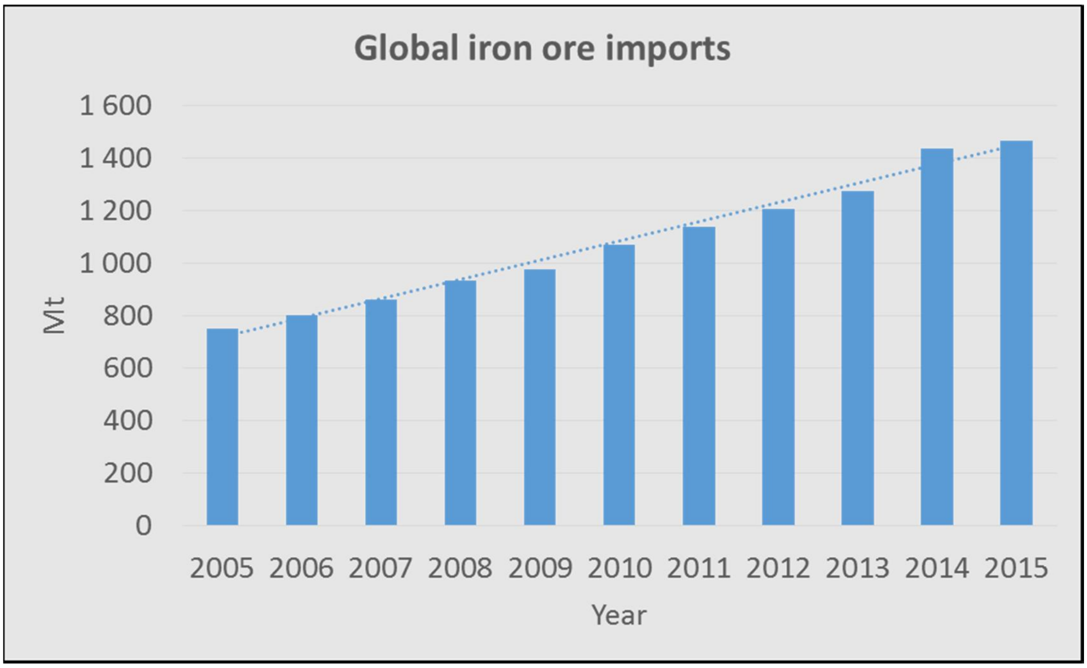

Figure 4.13: Global iron ore imports (Worldsteel Association, 2010-2016)

4.10 Chapter summary

The reduction in iron prices over the five-year period had a significant impact on the revenue and profitability of the four large market players. Over the five-year period from 2011 to 2015, the iron ore benchmark prices reduced from approximately USD150 per tonne to USD50 per tonne. In the period from 2011 to 2015, BHP increased output by 67 Mt to 226 Mt, RIO by 72 Mt to 263 Mt, Vale by 24 Mt to 346 Mt and FMG by 111 Mt to 169 Mt.

The increase in production/tonnage output assisted in reducing the operating cost of BHP, RIO and FMG by realising economies of scale benefits. As for Vale, the increase in output was minimal hence was unable to leverage the same benefit. The other significant contributor was the reduction in oil prices from 2014 to 2015 by 50% reducing the unit cost of production by approximately USD5 per tonne due to the high reliance on fuel for the operations. Freight costs reduced significantly from 2014 to 2015 by approximately USD5 per tonne from Australia to China and USD10 per tonne from Brazil to China due to the oversupply of ships and reduction in oil price (The Sydney Morning Herald, 2015).

For 2016, the derived operating profit margin (excl. SIB capital) for BHP and FMG is approximately USD22 per tonne for a benchmark price of approximately USD51 per tonne for 2015. Vale's derived operating profit margin was approximately USD20 per tonne and RIO was USD30 per tonne at a benchmark price of USD50 per tonne.

BHP and RIO had the lowest debt to equity ratio at 0.5 and 0.4, respectively in 2016. Vale debt to equity ratio in 2016 was slightly higher at 0.7 while that of FMG was 0.6. The four large producers dominate the iron ore market, both in terms of scale and lowest unit cost. The four largest companies essentially occupied quartiles one, two, and a large portion of three of the global cost curve during 2015. For 2015, the total global iron ore exports tallied 1.5 Bt, of which production from the four large producers was totalling 1.1 Bt (Worldsteel Association, 2010-2016).

The significance of the cost curves is that it provides guidance in terms of the cost at which iron ore can be delivered to meet demand. It is also an indicator of operating margins and profitability. The point where supply and demand meet, is defined as the spot price (Mckinsey and Company, 2009).

Chapter 5 will focus on the medium term outlook for the iron ore industry as a whole. It will consider analysts' reports and tools such as intensity of use as an indication of demand for iron ore.

5 SUPPLY AND DEMAND OUTLOOK WITH REFERENCE TO INTENSITY OF USE (POST 2015)

5.1 Chapter overview

Chapter five will focus on the medium to longer term outlook for iron ore. In broad terms, the medium term is defined as five years and the longer term a period exceeding five years for the purpose of this research report. A high-level analysis of the global iron ore reserves will be discussed to form an understanding of the availability of global iron ore reserves. As discussed previously, the significant growth from China spurred the demand for iron ore and the intensity of use theory will provide guidance for future consumption of steel. India will also be considered because it is likely to follow the Chinese trend due to its population size, low urbanisation rates and growing GDP. The rest of Asia is also seen to be critical in the longer-term demand for iron ore. The intensity of use for steel and indirectly iron ore will be compared with countries like USA, Japan and some European countries as a benchmark. The steel demand will be translated to the demand for iron ore considering the recycling potential. Recycling has a significant impact on the demand for iron ore and recycling in China is expecting to increase over the next decade. Various sources will be used as guidance documents to derive the potential outlook for the iron ore industry over the short to medium term period.

5.2 Iron ore global reserves

According to the U.S Bureau of Mines and U.S. Gelocial Survey (1980), the definition for a mineral resources is a “concentration of naturally occurring solid, liquid, or gaseous material in or on the Earth's crust in such form and amount that economic extraction of a commodity from the concentration is currently or potentially feasible”. They defined a reserve as “that part of the reserve base which could be economically extracted or produced at the time of determination”.

The global iron ore reserves play a significant role in forming a view on the medium to longer-term outlook for the industry. The availability of ore is a key determinant in the price formation, as well as the iron ore grades. Although longer-term sustainability is determined by various other factors such as location and cost of production, the reserve base underpins the extraction and market potential. Table 5.1 summarises the global iron ore reserves based on data from the USGS (2016). The iron ore grades are expressed as %Fe as it leaves the mine un-concentrated. The total reserve base is approximately 185 Bt - of which the majority is located in Australia, Russia, China, Brazil and India in that order. It is important to note the iron grade for China is very low at 31%, with the USA at 30%. As for the smaller countries on a reserve basis, the Ukraine and Kazakhstan have lower grade ores at 35% and 36%, respectively. South Africa has a small reserve base at higher quality of 65%. The reserves in Australia are very large at 54 Bt at an average grade of 44%.

Table 5.1: Iron ore reserves 2015 (USGS, 2016)

	Crude ore reserves (Mt)	**Iron content (Mt)**	**Fe%**
South Africa	1 000	650	65%
Kazakhstan	2 500	900	36%
Iran	2 700	1 500	56%
Sweden	3 500	2 200	63%
Canada	6 300	2 300	37%
Ukraine	6 500	2 300	35%
India	8 100	5 200	64%
USA	11 500	3 500	30%
Other countries	18 000	9 500	53%
Brazil	23 000	12 000	52%
China	23 000	7 200	31%
Russia	25 000	14 000	56%
Australia	54 000	24 000	44%
World total	**185 100**	**85 250**	**46%**

Table 5.2 summarises the global iron ore reserves based on data from the USGS, adjusted to a 62% Fe product specification. The total reserve base is approximately 137 Bt of which the majority is located in Australia, Russia, Brazil, China and India, in that order. At current depletion rates, the reserve life is in excess of 50 years indicating the abundance of the commodity (USGS, 2016).

Table 5.2: Iron ore reserves 2015 adjusted to 62% Fe (USGS, 2016)

	Crude ore reserves (Mt)	Iron content (Mt)	Fe%
South Africa	1 048	650	62%
Kazakhstan	1 452	900	62%
Iran	2 419	1 500	62%
Sweden	3 548	2 200	62%
Canada	3 710	2 300	62%
Ukraine	3 710	2 300	62%
USA	5 645	3 500	62%
India	8 387	5 200	62%
China	11 613	7 200	62%
Other countries	15 323	9 500	62%
Brazil	19 355	12 000	62%
Russia	22 581	14 000	62%
Australia	38 710	24 000	62%
World total	**137 500**	**85 250**	62%

Figure 5.1 provides a summary of the global iron ore reserves per country. Australia by far has the largest reserve base at 28%, followed by Russia at 16%, Brazil at 14%, China at 8% and India at 6%. Collectively the five said countries account for approximately 72% of global reserves (USGS, 2016).

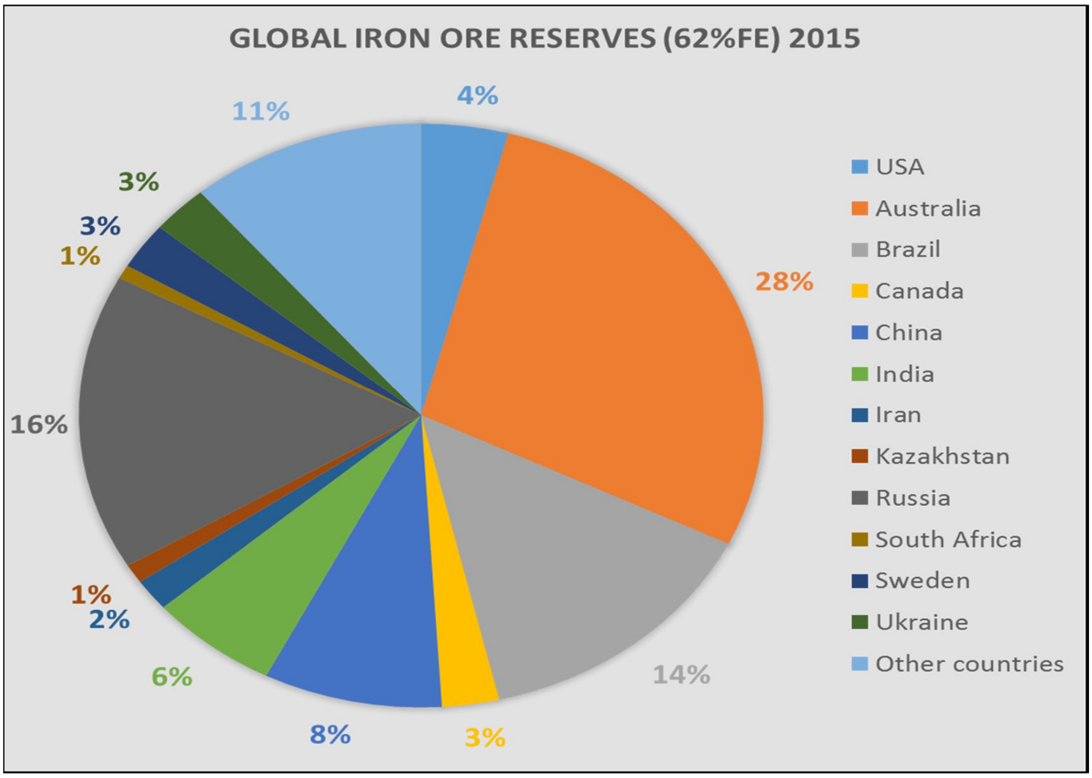

Figure 5.1: Iron ore reserves 2015 adjusted to 62% Fe (USGS, 2016)

5.3 Iron ore reserves for four largest iron ore producers

The reserves as discussed are from the various annual financial statements and reports for BHP, RIO, Vale and FMG. There are some differences in terms of reporting standards for various jurisdictions.

BHP's iron ore reserves at the time of reporting (June 2016) were 3.98 Bt in Australia at an average grade of 60.8% Fe, while in Brazil it was 62 Mt at an average grade of 43% Fe. The reserve life in Australia was 14 years and 2 years in Brazil at the time of reporting. BHP reports reserves and resources based on an adjusted ownership basis. The resources were 27.7 Bt at 61% Fe in Australia and 6.9 Bt at 37.7% Fe in Brazil (BHP Billiton, 2016).

FMG's reporting period ends 30th of June and the resources and reserves are based on financial statement reported as at the 30th of June 2016. The Hematite reserves were 2.17 Bt at 57.2% Fe, with the Magnetite reserves being 700 Mt at 27.2% mass recovery. The resources were 11.6 Bt at 56.8%

Fe, with the Magnetite resources totalling 6.7 Bt at 24.1% mass recovery (FMG, 2016).

RIO and Vale's resource and reserves are as per the 2015 December statements. RIO's reserves are reported on a shareholding basis to reflect the reserves related to RIO. The reserves were 4.2 Bt at 61.8% Fe. The resources on a 100% basis, not reflecting the RIO ownership component, were 25.3 Bt at a weighted average grade of 57.4% Fe (Rio Tinto, 2016).

Vale does not report on a shareholding basis and the numbers quoted are reflecting 100% shareholding. The reserves were 17.4 Bt at an average grade of 53.8% Fe. The four major producers have reserve life exceeding 10 years with significant resources in the pipeline. Although the potential increase in mining cost associated with the future extraction is not known at this point, it is clear that the resource and reserve base is very large and is capable of sustaining supply for a very long time (Vale, 2015).

5.4 Intensity of use

As discussed above, intensity of use provides an indication of future consumption of a particular commodity because of the transition between stages of economic development. The theory is based on the premise that the stage of economic development is represented purely by GDP/capita. Figure 5.2 illustrates the intensity of use for various economies such as the USA, Japan, France, Brazil, China and India. The USA, France and Japan represent the developed economies and indicate that the intensity of use starts to decline when the GDP/Capita is between USD15,000 and USD20,000. The graph also suggests that the consumption per capita starts flattening from USD10,000 per capita based on data from Japan, the USA and France. Three phases, as summarised in Figure 5.2, presents firstly the construction and infrastructure phase whereby economies consumes large amounts of construction materials and commodities. Secondly, a transition into a consumer led economy resulting in a slowdown in consumption per capita. The third phase is when there is a larger demand for equipment, motor vehicles and metal products such as household appliances (The World Bank, 2016).

Based on data from the World Bank (2016), the 2015 GDP/capita for China was approximately USD8,000 and India USD1,600. China is approaching the USD10,000 per capita mark. Figure 5.2 suggests that the steel consumption per capita may start losing momentum if China follows a similar path as Japan, the USA and France. Some outliers may occur, however, the trend is based on the fitted line for the data points reflected. India is still in the infancy stages of economic development on the basis of GDP/capita. Based on the intensity of use theory, it is expected that the use for steel in India will increase over time. It is also important to note that China went through a very aggressive urbanisation and construction phase never before seen in history and that India may not necessarily be as aggressive. The rate of economic growth and urbanisation have an impact on the demand for commodities. As eluded to in Chapter 3 of the research report, there is a direct correlation between steel consumption and the demand for iron ore. Recycling of steel is essentially the only aspect that will result in the demand for iron ore not correlating with the demand for steel. This will be discussed later in this chapter.

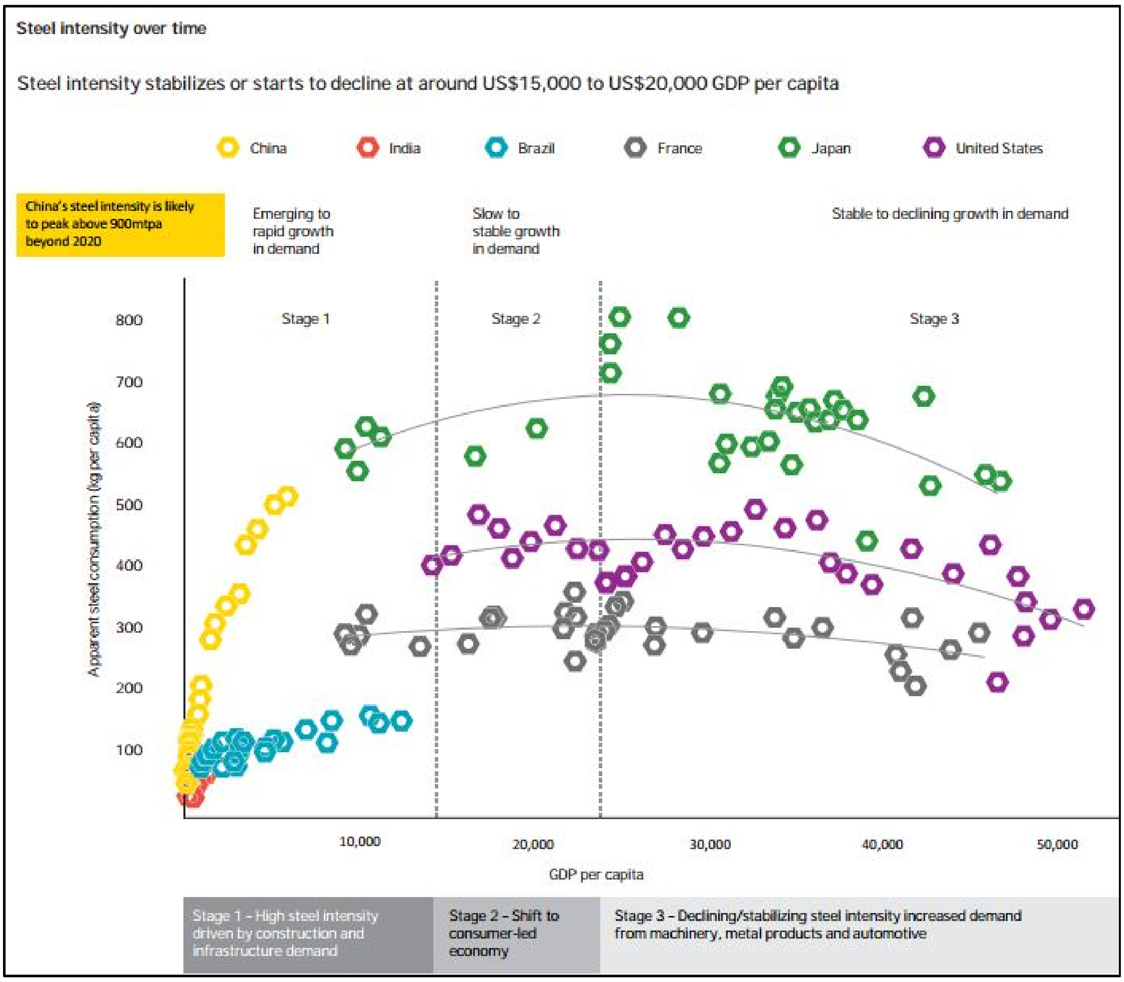

Figure 5.2: Steel intensity of use (nextBigFuture, 2015)

China is likely to continue on its economic development growth path, based on data analysed and growth targets committed to in the five-year plan. The growth is likely to be much slower than the last decade, but still significant in global terms. China is likely to follow a similar path as the USA and Japan for their apparent steel consumption per capita as the economy transitions. Considering the recent growth in terms of GDP/capita, China could be approaching USD15,000 per capita by 2020/21 and USD20,000 per capita at around 2024/25. It would appear that China will continue to drive the increase in demand for global iron ore, at least in the medium term.

5.5 Iron ore industry outlook from analysts

According to a research report by ANZ (2015), the 2014 drop in iron ore prices appear to be extreme, however, 85% of the seaborne industry was still making money at the time the research report was compiled. According to the report, the main driver behind the drop in prices was as a result of substantial new iron ore supply entering the market in a weakened demand environment. At this time, the high cost Chinese producers were not responding in terms of withdrawing supply. ANZ forecasted an iron ore price, delivered in China, at around USD60/tonne for 2016, USD63/tonne for 2017 and USD65/tonne for the period 2018-2020.

According to a research report by ANZ (2015), the elevated iron ore prices during 2010 and 2011 resulted in FMG, RIO and BHP committing over USD10 billion in expansion projects. During 2013, the three majors increased output by 100Mt of iron ore exports, 3 times higher than the historical increase of 30Mt per year over the last decade. This resulted in a significant over-supply situation driving prices down. The low cost of production from the four major producers is placing the higher cost producers under pressure. ANZ forecasts an oversupply of iron ore to the extent of approximately 80 Mt for 2016 and 2017, reducing to below 60 Mt from 2018. Peak steel consumption from China is forecasted at 841 Mt in 2020 after which a slow-down in consumption is predicted. Equating to an annual growth rate of 2.9% year on year predominantly driven by infrastructure and less by real estate.

According to a research report by ANZ (2015), supply from the Chinese iron ore producers appear to have been very inelastic with falling prices. The expectation was the supply would be reduced as a result of falling prices and high cost operations. There is a view that royalty relief for state owned iron ore companies in China, making up 80% of all iron ore mines, resulted in supply not being withdrawn from the market. On the basis of state owned entities being vertically integrated, high cost Chinese iron ore production is not seen to be a good indication of how price should react in an oversupply market. Seaborne supply provides a better indication of how prices should react. The sharp drop in oil prices resulted in a lower cost of production and transportation, which made lower prices sustainable for some producers.

According to a report by Ernst & Young (2014), approximately 30% of Chinese steel production is consumed by the property market. The biggest risk from global steel demand is the slowdown in domestic real estate in China. The residential property sales in 2014 and first quarter 2015 dropped by 9% year on year. There is significant spare steel mill capacity available in China at present and is estimated at 30% with the current utilisation being only at around 70%. There is, however, a possibility that new regulations would result in some of the older, more polluting steel mills closing down rebalancing capacity.

A report by CRU (2016) suggests that the market is currently structurally oversupplied. They also suggest that due to the oversupply situation there is an expectation that prices will fall from the USD59/DMT levels at the time of publication (October 2016). There is a concern that the S11D project from Vale, which will bring large quantities of low cost iron ore to the market, will drive prices even lower. The project is expected to deliver 90 Mtpa from 2021 when at full capacity. CRU is of the view that should the project ramp-up be delayed, iron ore prices could range from USD55 per tonne to USD70 per tonne. The iron ore price forecast from CRU suggests that prices on a 62% Fe CFR China basis (nominal terms), will be USD49 per tonne for 2017, USD48 per tonne for 2018, USD64 per tonne for 2019 and USD65 per tonne for 2020. According to CRU the breakeven price for major seaborne exporters, on a 62% Fe CFR China USD/tonne basis, is USD27 per tonne for RIO, USD29 per tonne for BHP, USD32 per tonne for FMG and USD34 per tonne for Vale fines only.

Recently, Chinese iron ore supply reduced by 65 Mt. CRU (2016) is of the opinion that the reduced domestic Chinese output is mainly due to stricter environmental legislation. There was a clear improvement in real estate prices recovering to a growth rate of 10% year-on-year mid 2016 up from -5% during the second half of 2015. Infrastructure spending during 2016 increased to a growth rate of 20% during the first half of 2016, up from -20% during the second half of 2015. The increase in growth in real estate and infrastructure supported higher iron ore prices. CRU (2016) predicts that the stimulus will wear out and the steel production in China will reduce to a range of between 850 Mtpa and 860 Mtpa over the next few years. A further 197 Mt of low cost seaborne iron ore supply will make its way to the market during the next five years. This will mainly be delivered by Samarco, Vale, Roy Hill, BHP and RIO. This will lead to high cost suppliers to exit the market, some from China and some from other seaborne suppliers. CRU (2016) predicts the seaborne market will peak in 2020 at around 1.54 Bt. The availability of scrap steel in China is not seen as a short to medium term threat, but according to CRU it will start to impact the market materially by 2027. According to CRU, the iron ore price should trade close to marginal cost and range between USD 49/tonne to USD 65/tonne over the period 2016-2020.

A report by City GPS (2015) suggests that the 2002 to 2010 commodity boom was predominantly driven by China's urbanisation and infrastructure build programme. According to City GPS there is no single replacement for China and the next decade will be driven by the emerging five, namely: India, South East Asian Nations, Middle East, Latin America and Africa. The overall economic growth in China is slowing and the coming decade will face a structural slowdown in Chinese demand growth. City GPS predicts that the emerging market steel demand will grow by a modest 2.5% per annum over 2020 to 2025 from 11% growth over the period 2001 to 2011.

City GPS (2015) suggests that the Chinese government is focusing on slowing the rapid increase in government debt and this will be done through reduced investment into infrastructure and real estate outside large cities. The other reason for rebalancing is the required shift from investment to consumption to reduce the investment share percentage of GDP. The growth in China was largely driven by investment rather than consumption. Due to China's significant exposure to real estate and infrastructure, it is expected the demand for bulk commodities will peak around 2025 according to City GPS. ForcIndia to undergo rapid growth, it would require policy reform, political stability and a large urbanisation and infrastructure drive. It is, however, expected that the demand for steel will increase at an annual rate of 8.2% for 2014 to 2020 and 7.5% for 2020 to 2025.

According to the Minerals Council of Australia (2015), iron ore prices will trade at prices closer to the long-run average. The long-run average price between 1980 and 2005 was USD30/tonne FOB. In order for prices to be sustained at levels much higher than the long-term averages, it would require a genuine shortage of a commodity or across-the-board decline in grades. During a period of strong production growth from the early 2000's saw large scale, low cost operations being introduced. Production cost fell across the majority of the sector with production volumes increasing, resulting in prices falling. Vale is planning to bring large volume, low cost production to the market by 2018, which will effect the market. The policy paper also insist that in order to stay competitive, one must keep focusing on improved efficiencies and reduced cost.

Based on the data analysed and information researched, the iron ore market is currently structurally over-supplied and can easily meet demand. It is likely that China will continue to drive the global increase in iron ore demand in the medium term. India is likely to increase demand albeit at a much slower rate than China and is not expected to be significant in the medium term. There are a number of large scale, low cost expansion projects, which will in all likelihood meet the additional demand from China over the coming years. The prices are not expected to increase significantly in the medium term and is likely to trade between USD50/tonne and USD70/tonne.

5.6 Chapter summary

The iron ore reserves play a significant role in formulating a view on the outlook and sustainability for the iron ore industry. The global reserves, based on data from the USGS (2016), is 185 Bt with an average grade of 46%. When adjusted to a 62% Fe product specification, there are 137 Bt global reserves. The reserve life is approximately 70 years at current extraction rates, clearly indicating that it is not a scares commodity. The countries with the majority of the resources are Australia, Russia, Brazil, China, USA and

India making up 77% of the global reserves. The four largest iron ore producers, namely BHP, RIO, FMG and Vale have very significant high-grade resources and reserves able to support their business for a long time to come. Supply security does not seem to be a major challenge. The growth in demand for iron ore will largely determine the iron ore price. The intensity of use model provides guidance for what the demand may look like considering the stage of economic development.

Intensity of use is a good measure because it can be used as a demand-forecasting tool, considering the stage of economic development. Adequate data is available for developed economies as they transitioned which provides for a useful benchmark. The theory of intensity of use is based on the premise that the demand for certain materials will reduce as an economy moves from manufacturing to a services economy. History based on Japan, the USA and France shows that the consumption of steel per capita correlates well with the GDP/capita. When the said developed economies approached a GDP/capita of USD15,000, there appears to have been a reduction in demand for steel. The data also suggests that the momentum in consumption per capita reduces when GDP/capita approaches the level of USD10,000. China being the largest consumer of steel is currently at a GDP/capita of USD8,000 and nearing the USD10,000 mark. Data from various sources suggests that there is a slowdown in China’s construction activity and demand for steel.

The prices for iron ore were significantly impacted by cheaper supply coming on line. The market is currently in an over-supply situation and due to the price inelasticity of the state owned Chinese iron ore mines, the market is reacting slowly to the over-supply situation. The seaborne demand is seen to be a better measure for iron ore demand. During periods of high iron ore prices, significant production was introduced, exceeding the demand growth from China. The additional supply was also from large scale, low cost operations. Over the same period, oil prices reduced significantly effecting the cost of production and cost of freight. A combination of over-supply, significant additional low cost production, inelastic Chinese iron ore supply, a reduction in operating cost due to oil prices and improved efficiencies resulted in the prices falling sharply.

The growth in demand for global steel is not expected to grow significantly during the next decade as a result of China's slowing growth and other key economies not being in a position to make up for it. Recycling of steel will increase over time, especially in China where the availability of scrap steel will increase over time. Some Chinese production will most likely be removed but the state owned operations might remain in operation. The pressure will rather be on high cost seaborne iron ore production. Additional high volume, low cost production is planned to come on line during 2017 and 2018, mainly from Vale.

The additional supply will place additional downward pressure on prices and will have a favourable impact should ramp-up be delayed for whatever reason. The total iron ore exports/imports were 1.5 Bt for 2015, of which China imported 950 Mt. The four large iron ore companies produced 1 Bt during 2015, effectively meeting the entire Chinese import demand, at the lowest position on the cost curve. As discussed in Chapter 4, the four largest producers occupy quartile one, two, and about half of quartile three on the cost curve on an export basis. The demand for iron ore in China will increase slightly over the next five years and the only possibility for a significant increase in import demand will be if the state owned iron ore mines stop operating. There are various iron ore price forecasts, but in general they appear to be in a range of USD50/tonne to USD70/tonne in nominal terms over the next five years up to 2020.

6 KEY DRIVERS OF IRON ORE DEMAND AND IMPACT ON PRICE

6.1 Chapter overview

This chapter aims to provide an overview of the linkages between the various fundamentals and factors underpinning iron ore demand and the impact on price. It aims to summarise the key fundamentals and data discussed in chapters two to five.

6.2 Demand driven by growth in global GDP

The literature review from Chapter 2 on cycles and super cycles seems to suggest that the world entered a fourth super cycle during 2004 with the rapid urbanisation and industrialisation of China. It also suggests that the demand for non-oil commodities is primarily driven by world GDP and essentially global economic growth. The intensity of use method shows the correlation between economic growth and consumption of a particular commodity. The primary use of iron ore is steel manufacturing and 98% of all iron ore is used for steel manufacturing. As such, steel consumption provides a good proxy for iron ore consumption. Figure 3.5 clearly illustrates the high level of correlation between apparent steel consumptions and global GDP, confirming the views from the literature review. Global GDP was primarily driven by China over the period 2005 to 2015.

From Figure 2.3, the global GDP growth per annum from 1990 to 2014 was slightly below 3%. When considering the period in question, 2005 to 2015, the global GDP growth per annum was 2.5%. This included the GFC from 2008, resulting in a lower average annual growth rate. The annual average growth rate from China over the period 2005 to 2015 averaged 10%. Considering the size of China's economy (see Figure 2.4) as the second largest global economy, the growth rate was very significant on a global basis. Data from the World Bank (2016), suggested that China accounted for 5% of the world GDP in 2005 and increased to 15% in 2015. That means China contributed approximately 0.9% of the 2.5% total global growth, making it very significant. It is therefore evident that the economic growth in China supported global growth as shown in Figure 2.2, which in turn supported the demand for iron ore.

6.3 Demand driven by construction sector consumption

Figure 3.1 provides an overview of the global steel consumption per sector for 2013, which suggests that construction accounted for 50-60%, machinery for 20-25% and automotive 6-7%. The steel consumption per sector for a developed economy, as per Figure 3.2, is 36% for construction, 11% for machinery and 22% for automotive. The global average seems to suggest that the demand for steel is primarily driven by construction from emerging economies.

According to MESTEEL (2016), the top ten countries on the basis of iron ore consumption account for approximately 75% of the global consumption and provide a good indication of the market direction. From Figure 3.3, the apparent steel consumption grew at an average annual growth rate of 3.8% with 2008 and 2009 showing a significant reduction because of the GFC. The period 2014 and 2015 also showed a significant reduction in growth. From Figure 3.4, the top ten countries, excluding China, grew at a modest average annual growth rate of approximately 1%, helped primarily by the growth of India, which grew by an average of 7% per annum.

The steel consumption in China grew at an annual average rate of 6.7% over the period 2005 to 2015. From Figure 3.4, it is evident that China experienced a significant slowdown in steel consumption during 2014 and 2015 and was adversely impacting on global steel consumption. It is fair to conclude that the global steel consumption over the period 2005 to 2015 growth was as a result of growth in construction sectors of China and India. China was the primary driver accounting for approximately 71% of the steel consumption growth over the ten-year period and when combined with India, collectively accounting for approximately 81% of the growth.

6.4 Impact of recycling on iron ore demand

Recycling of scrap steel has a material impact on the demand for iron ore. From table 3.3, old scrap utilization in steel manufacturing increased from 166

Mt (2005) to 228 Mt (2015). That is a 62 Mt increase in old scrap consumption per year, impacting the demand for iron ore. During 2005, the impact of steel recycling on the demand for iron ore accounted for approximately 270 Mt per annum and increased to approximately 367 Mt per year by 2015. From Figure 3.16, the recycled scrap steel accounted for approximately 15% of steel production during 2015. Recycling is significantly higher in developed economies and this number is expected to increase over time as scrap steel becomes available in developing economies as a result of ageing infrastructure. The derived iron ore demand for 2015 was 2 Bt for the global market.

6.5 Iron ore supply and balance

The global iron ore supply from Figure 3.21, normalised to a 62% Fe product specification, increased from 1.36 Bt in 2005 to 2.5 Bt in 2015. That is an average annual growth rate of 6.3%. Approximately 90% of the increase in iron ore output, on a 62% Fe basis, was from China, Australia and Brazil. China increased supply by 445 Mt (62%Fe), Australia by 560 Mt (62%Fe) and Brazil by 138 Mt (62%Fe) over the ten-year period.

The four largest global iron ore producers, namely: BHP, Vale, RIO and FMG, accounted for approximately 40% of the 2015 global production. They also accounted for approximately 80% of the increase in production from Australia and Brazil. From Figure 3.22, iron ore production from the four majors increased by 552 Mt over the ten year period from 453 Mt in 2005 to 1 Bt in 2015. According to Worldsteel Association (2016), the total imports/exports for 2015 were 1.5 Bt of iron ore of which the four majors account for approximately 67%. The four majors export the majority of their product to Asia.

Based on data from the USGS (2016), global iron ore reserves were at 185 Bt in 2015 at an average grade of 46% Fe. This equated to a reserve base of approximately 70 years at current levels of consumption. China and USA predominantly have low-grade reserves at approximately 30% Fe, compared to the rest of the world average of 50% Fe.

Based on supply and demand, it is clear from Figure 2.23 that there was a material over supply of iron ore during 2014 and 2015. The iron ore demand for 2014 and 2015 was approximately 2 Bt and the supply was approximately 2.5 Bt. The documented supply of iron ore, either from a quantity or quality point of view, could skew the supply demand-balance. Based on the annual data, there was never an iron ore supply deficit for the ten-year period in question.

From the data, one could conclude that supply was able to continuously increase to meet demand over the period in question. This is consistent with the fact that iron ore is not a scares commodity. The Chinese iron ores are predominately of low quality and the significant increase in low-grade supply impacted the cost of production and break-even price. This is clearly evident in the cost curve as per Figure 4.11. Cost of production is, however, a driver for demand and if too high will start impacting on demand.

6.6 Iron ore price

Price determination changed from longer term contracts to spot prices during 2008, which resulted in iron ore prices experiencing higher levels of volatility. To understand the link between supply, demand and price of iron ore, one must have a good understanding of the industry cost curves. When overlying the price on the cost curve from 2005 to 2015, it provides an indication of the point where supply and demand are in equilibrium.

Considering Figure 3.24, the supply increase during periods of elevated prices and the demand reduced following a period of highly elevated prices. This correlation is in line with supply and demand economics. The market was materially over-supplied during 2014 and 2015 when the iron ore prices collapsed. The correlation between supply, demand and price is not that evident on an annual basis. The data seems to suggest that the market was over supplied by as much as 30% at the time of the price collapse. Leading up to 2014, the over-supply was in the order of 20% and even lower pre-2010.

From Figure 6.1 there appears to be some correlation between apparent steel consumption annual growth rate and iron ore price post 2008. Coincidentally, 2008 was the period where iron ore price determination moved from longer term contracts to spot prices. Sufficient data is not yet available to analyse this further or to conduct a statistical analysis however it would appear that prices react to growth rates and indirectly expected consumption levels. The statement is plausible since a reduction in steel consumption growth rates directly relates to reduced demand for iron ore as explained in Chapter 3. This will mean that the demand could be met at a lower supply cost at that particular point in time as per the global iron ore cost curve as explained in Chapter 4. The over-supply of iron ore will result in reduced prices for iron ore.

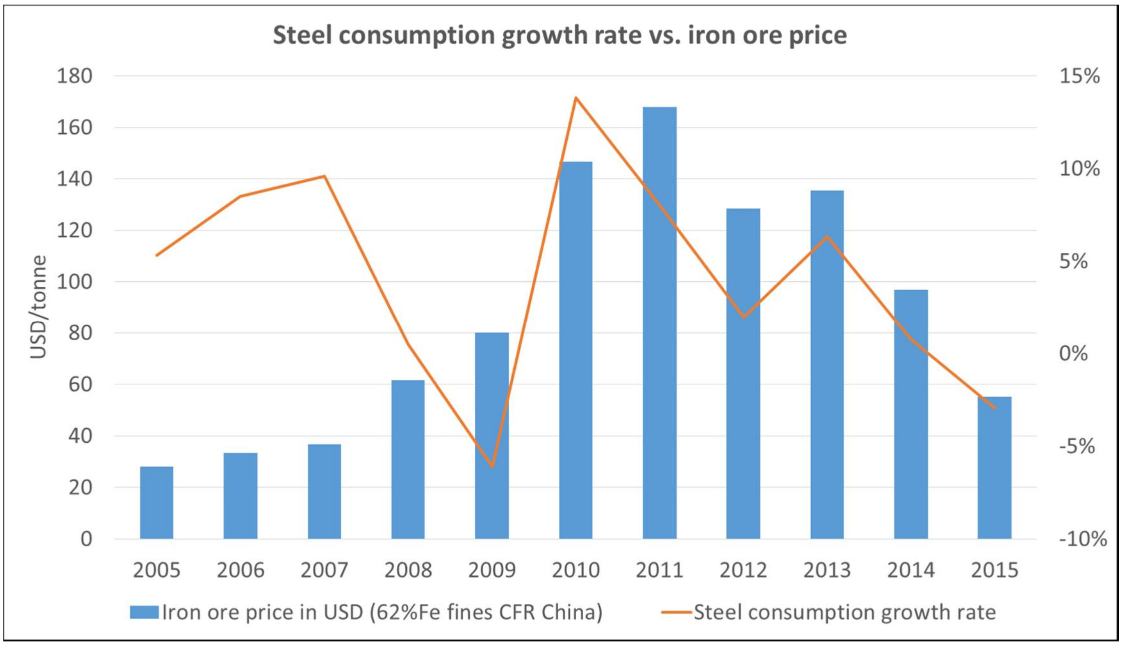

Figure 6.1: Steel consumption year on year growth rate vs. iron ore price from 2005 to 2015 (Worldsteel Association, 2010-2016 and USGS, 2016)

6.7 Cost of production of iron ore

The cost of production is a key driver for iron ore demand. The point where supply and demand are in equilibrium defines the market price. When input cost, representing the majority of supply reduces, such as diesel, supply will be available at a lower cost of production resulting in the supply curve moving down. Demand can be met at a lower price driving prices down and then once again driving demand. Alternatively, more supply is available at the same price. When prices are excessive for extended periods, it will start impacting demand negatively as it will reduce.

The iron ore price is impacted by global oil prices. Reduced oil prices will result in the reduction of the production cost of most iron ore producers if not all, which will result in the cost curve moving downwards. Because of this, higher quantities of iron ore will be available at the same price. Should there be no immediate increase in demand, the iron ore prices will reduce since the demand could be sufficiently met at a lower production cost. Diesel cost makes up approximately 30% of the mining cost for most iron ore mines as explained in the section discussion macroeconomics. Transportation cost in the form of rail and freight is heavily dependent on the cost of oil. The crude oil price reduction reduced the cost of production for iron ore delivered to the market by approximately USD10/DMT to USD20/DMT between 2014 and 2015. This partially explains why the cost curve moved lower as shown in Figure 4.10. Most companies undertook efficiency drives to reduce cost, which also resulted in the cost reducing. Large scale, low cost projects delivered by BHP, RIO and FMG resulted in the cost curve shifting to the right as low cost iron ore displaced higher cost iron ore, meaning there was more iron ore in the market at lower cost. The delivery of large-scale projects also benefitted the cost of production from a scale of economy perspective. Figure 4.11 clearly shows that quartile four of the cost curve is predominantly occupied by the Chinese production, mainly because of the low-grade reserves. This confirms that high cost Chinese production was introduced to the market during times of high prices, whereas the likes of BHP, RIO, Vale and FMG introduced additional low cost supply. Excess high-cost supply is not sustainable over time and will eventually fall out. The cost of production impacts profitability significantly and the profitability of a business is critical to sustainability and continued supply.

The four major iron ore producers are viewed to be the market leaders. In Figure 4.8, the EBITDA margins of BHP, RIO, Vale and FMG were reduced from a range of 66-72% (excluding FMG) to a range of 33-53% over the five-year period from 2010 to 2015. The four major producers were still profitable at low iron ore prices, however, prolonged periods of low prices will place strain on the balance sheet. The debt to equity ratios increased from 0.2 to 0.3 (excluding FMG) to 0.4 to 0.7 during the same period, placing the balance sheet of the four majors under pressure. In Figure 4.6 and Figure 4.7, BHP, Vale and FMG had an operating profit margin of USD20/tonne to USD22/tonne and RIO, USD30/tonne in 2015 when the iron price averaged USD50/tonne.

Profitability of low cost, major producers is important in the context of sustainable supply. During times of oversupply, it is entirely possible for the price to fall below break-even cost even for the low cost producers. It is, however, not sustainable and when the large scale, low cost producers cannot service their debt, supply would be at risk. The high cost producers are placed under severe pressure when prices are low for an extended period of time, resulting in supply being removed from the market. Profitability informs sustainability of supply at that particular cost of production, which impacts the demand for the said commodity.

6.8 Chapter summary

There is most certainly a correlation between global GDP or global economic growth and the demand for steel and indirectly iron ore. World GDP growth over the last decade was predominantly driven by China as the largest emerging economy and secondary by the USA as the largest developed economy. The global increase in apparent steel consumption was primarily driven by China, then India. Recycling of steel impacts the demand for iron ore and is currently limited to approximately 15%. This is expected to grow over time as the infrastructure from emerging economies such as China ages and will have an increasing impact on the demand for iron ore. Iron ore is not seen as a scarce commodity and is abundant across the world, although concentrated in certain countries. China imported 950 Mt of iron ore during 2015. The iron ore reserves in China is of low grade and considering the vast amounts of iron ore consumed by China, seen to be insufficient. The Chinese iron ore reserve base if 23 Bt at an average grade of 31% Fe. Considering current consumptions levels, if China were to consume its own iron ore reserves, it would last approximately 10 years at current consumptions levels. The cost of production would also be high because of the inherent low grades. This supports the Chinese import strategy for iron ore to secure supply and meet demand.

The iron ore imports to China increased steadily over the ten-year period. The annual apparent steel consumption growth rate did, however, vary significantly and there appears to be some correlation between apparent steel consumption growth rates and iron ore price. The cost curves shifted downwards during 2014 and 2015, amongst other reasons due to the reduction in oil prices as well as efficiency improvements and cost savings. It moved to the right mainly because of low cost, large-scale production brought on stream. The four large producers increase output by approximately 550 Mt over the ten-year period. The global supply was able to meet the demand, however, it included significant amounts of high cost Chinese production, which pushed the prices higher.

The key drivers impacting iron ore demand are global GDP growth, industrialisation and urbanisation of emerging economies, recycling of steel, supply and demand balance of iron ore, the cost of production and the price of global iron ore. The iron ore market is structurally over-supplied at present and supply can easily meet demand. According to analyst views, this situation is unlikely to change during the short to medium term. The cost of production is significantly influenced by the oil price, since it is a significant input cost for most suppliers and will influence the entire cost curve to some extent.

7 CONCLUSIONS AND RECOMMENDATIONS

The global iron ore prices experienced significant increases from 2005 on the back of the unprecedented Chinese industrialisation and economic growth. The iron ore prices peaked during 2010 and collapsed during late 2013. The market has posed significant challenges for iron ore producers from a profitability, as well as strategic positioning perspective. Anglo American has interests in iron ore assets in South Africa and Brazil and currently employs the author. Understanding the key drivers effecting iron ore demand, as well as the impact on price provides good context to influence and inform strategic decision-making.

It is a major challenge positioning iron ore assets in a market as volatile as experienced during the last five years. The primary objective of the research report is to determine the key drivers effecting iron ore demand. The supply and demand balance and impact on iron ore price are seen to be key in understanding the broader iron ore market. The broader objectives were to:

- Determine from literature review if the rise and fall in iron ore prices over the last decade (2005-2015) are typical of a commodity super cycle and if the recent collapse is a market re-adjustment or the end of the super cycle that started in 2005.
- Determine the key drivers for global iron ore demand.
- Analyse the global iron ore supply and demand over the period 2005 to 2015.
- Determine the impact of the global iron ore price collapse on the profitability and sustainability of the four major producers.
- Research the medium term outlook for the iron ore industry with consideration for intensity of use as a proxy for iron ore demand.

The scope was limited to the supply and demand analysis over the period 2005 to 2015. China was identified as the key economy impacting on the global iron ore demand. The profitability analysis was limited to the four largest global iron ore producers namely BHP, RIO, Vale and FMG. The scope for the profitability analysis was limited to the period 2010 to 2015.

Cuddington and Jerrett (2008) broadly defined four commodity super cycles experienced so far which were caused by the rapid economic expansion of the United States of America; the resurgence of Europe after World War II; the emergence of Japan; and lastly the China growth story. There are two main reasons why cycles are classified as super cycles. The first reason is that super cycles are long cycles with a typical upswing of 10 to 35 years and a complete cycle of 20 to 70 years. The second reason is that it is broad based insofar as a wide range of commodities being effected. Erten and Ocampo (2012) confirmed the views of Cuddington and Jerret (2008) and added that the demand for commodities during a super cycle is typically driven by industrialisation and urbanisation of developing economies.

There is sufficient research to draw a conclusion that the emergence of China was seen to be the start of the fourth super cycle. The iron ore prices increased significantly over a ten-year period from 2004/5 to 2013/14 with some volatility over the period, due to shorter term factors at play. This meets the minimum requirements as defined in the literature for a typical upswing of 10 to 35 years. The complete cycle should be a minimum of twenty years to meet the requirements of a super cycle as defined in the literature review. Sufficient data will only be available in a number of years to test the literature review fit. The second criteria have not been tested insofar as a broad range of commodities affected since this report focused only on iron ore. Although it is difficult to ignore the collapse of iron ore prices during late 2013/2014, one cannot conclusively say that it signalled the end of the said super cycle. On that basis, the conclusion drawn, based on the data available at present, is that the iron ore market experienced a market re-adjustment. There is however concerns about global growth mainly because of the slowdown of the Chinese economy which may result in lower iron ore prices and consequently steel in the medium term. India will require significant policy reform to mitigate the China slow down and provide support for steel demand.

The key drivers impacting iron ore demand are global GDP growth, industrialisation and urbanisation of emerging economies, recycling of steel, supply, demand balance of iron ore, cost of production and the price of global iron ore. Since the market is currently structurally over-supplied and demand can be easily met, iron ore prices will continue to remain under pressure.

There is good correlation between global GDP and apparent steel consumption. This confirms the views from Cuddington and Jerrett (2008) as well as Erten and Ocampo (2012) that super cycles are demand driven. Approximately 98% of all iron ore is used for steel making. On that basis, the demand for steel is a key driver for the demand of iron ore. One of the key drivers for demand for steel and indirectly iron ore is global GDP growth as per the literature review and the data analysed. When considering the intensity of use method, the steel consumption per capita will increase with GDP/capita growth suggesting that the transition from agriculture to industry requires more steel. When transitioning from an industrial (manufacturing, construction, mining, water, and energy generation) economy to a services economy, there is a reduction in steel consumption per capita. According to Worldsteel Association (2010-2016), the steel consumption is primarily driven by construction and manufacturing underpinned by urbanisation due to new demand for housing, infrastructure, transportation, and services. Emerging economies are the main driver behind global GDP growth. The global annual GDP growth over the last decade was just under 3%, with the exception of 2008/2009 because of the GFC. China accounted for just under 1% or a third of the global GDP growth in 2015. This highlights the significance of China as a key driver for global GDP growth. China underwent a period of significant growth, industrialisation and urbanisation. Chinese growth started showing signs of a slow down during 2012. India is showing increased economic growth and associated urbanisation levels.

From a demand perspective, the increase in apparent steel consumption over the last decade was primarily driven by China and, less significantly, by India. China doubled its apparent steel consumption from 327 Mt to 672 Mt as did India from 39 Mt to 80 Mt over the ten-year period from 2005 to 2015. The increase in steel consumption from China and India accounted for 80% of the global increase. On that basis, China and India are once again confirmed as key emerging economies effecting the steel and iron ore industry.

Recycling of scrap steel is a key aspect effecting new steel demand. Steel recycling currently account for almost 15% of steel production and it is expected to increase over time because of ageing infrastructure in developing economies. The demand for iron ore is based on the steel consumption minus the impact of scrap steel recycling. Iron ore demand, derived from consumption and recycling, increased from 1.35 Bt in 2005 to 2 Bt in 2015.

Iron ore is an abundant commodity and supply is not dependent on availability but mainly on price. The demand over the last decade was easily met as a result of increasing iron ore prices, however, it meant that high cost producers entered the market, such as a significant portion of the Chinese iron ore mines. They are predominantly high cost producers mainly due to their inherently low iron grades. Iron ore production and supply increased significantly from Australia, Brazil and China. Brazil increased its output of 62% Fe (iron ore) by 138 Mt, Australia by 560 Mt and China by 445 Mt, with China being the highest cost producer. The major companies that significantly expanded their operations were RIO, BHP, Vale, and FMG. Their collective output increased by approximately 550 Mt from 450 Mt in 2005 to 1 Bt in 2015.

There is approximately 70 years of iron ore reserves available at 2015 consumption rates and not posing any supply risk. When demand reduces, it can be met at lower prices due to the steep cost curve of the fourth quartile producers. The new iron ore supply introduced to the market over the last decade from Australia and Brazil, was mainly large scale, low cost operations and moved the cost curve to the right displacing high cost producers (see Figure 4.10). The oil price also effected the cost of iron ore production and with falling oil prices from 2014 to 2015, the cost curve was moved downwards as a result. Efficiency improvements and cost reduction initiatives also contributed to the reduction in the cost of production. If high cost State owned Chinese iron ore operations and some of the marginal operations were to be closed for a period of time, higher iron ore prices could be supported, as the current over-supply situation would be mitigated. Further large scale, low cost production being introduced to the market would result in the prices coming under pressure again since there will be more low-cost production available to meet demand. A material slowdown in economic growth in China would result in a reduction in iron ore demand, impacting on prices.

The lower iron ore prices from 2014/2015 onwards, placed a number of the iron ore producers under pressure. The four major iron ore producers namely BHP, Vale, RIO and FMG all experienced significant reductions in profitability similar to the other producers. BHP, Vale, RIO and FMG are the market leaders from a production and cost perspective. Besides the EBITDA margins reducing significantly, the debt to equity ratios also increased significantly which resulted in a higher risk of not being able to service debt.

Most analysts are predicting that China will continue to grow albeit at a much slower rate than before. The prediction is that apparent consumption of steel will increase until 2020 as the GDP/capita increases as well. A slowdown in apparent steel consumption is expected from China post 2020. The iron ore price forecasts range between USD50/DMT and USD70/DMT until 2020. On that basis the medium term outlook for low cost iron ore producers are good. The high cost producers, with costs exceeding USD70/DMT, will continue to struggle and face significant squeezed profit margins. The question is how long will the Chinese state owned iron ore operations continue to run at a loss before they are moth balled.

It is recommended that a detailed shorter interval analysis, as opposed to annual, is conducted on steel consumption growth rates and iron ore price to test the level of correlation. A shorter interval analysis on the supply and demand balance should also be undertaken to determine the correlation with price, since it is not all that clear when considering the annual data. Supply however, increased during periods of elevated iron ore prices and demand reduced during prolonged periods of subdued prices as per the economics of supply and demand.

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