Iron Ore Market in India

LSI GROUP

2024

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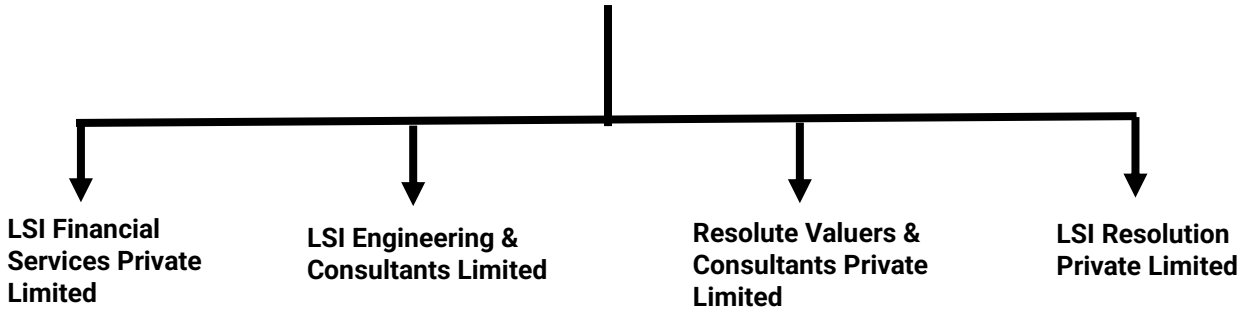

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EXECUTIVE SUMMARY

- The report on India's Iron Ore Market highlights the high demand for this resource due to its intricate nature, market dynamics, production and consumption trends, and prospects.

- India ranks seventh globally in iron ore production, with 35.284 billion tonnes of magnetite and hematite resources. The top producing states are Odisha, Jharkhand, and Chhattisgarh. The steel industry is the primary consumer, with 236 million tonnes consumed in 2021-2022, indicating a compound annual growth rate of 8.21% from FY12 to FY22.

- The Indian iron ore market is highly competitive, influenced by factors like price, reserves, export demand, industrial output index, and consumption patterns. Regression analysis is used to determine the average impact of these factors on dependent variables like production and consumption. Two forecasts for 2035 iron ore production and consumption are proposed: a moderate estimate of 677 million metric tons, compared to 632 million tons of consumption, and an optimistic estimate of 873 million metric tonnes against 832 million masses of demand. The production side model indicates a negative correlation between iron ore output and inventory during the lag period.

- India's iron ore consumption is primarily driven by downstream industries and forward-linkage markets, used in electric arc furnaces and blast furnaces for iron production. Technological advancements have reduced demand, but steel consumption is strongly correlated with iron ore consumption. Demand is not elastic, and domestic pricing reflects this. Steel production primarily uses blast furnaces, but mills are transitioning to electric-arc furnace technology, using scrap steel and sponge iron.

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Introduction

Iron and steel industry has the paramount significance behind economic growth and development of the Indian Economy. The mining of iron ore which is one of the major inputs in the steel-making process, conceivably has supreme importance in any country. With total resources of over 35.284 billion tonnes of hematite (Fe_2O_3) and magnetite (Fe_3O_4), India is one of the **leading producers (fourth) and ranks seventh in terms of reserves of iron ore** in the world. India is not only one of the leading producers of iron ore but also at present second largest manufacturer of steel in the world.

Though the country can boast of huge quality iron ore resources, the percentage of reserves to total resources is quite dismal as only 24% of hematite and mere 0.49% of magnetite resources are categorised as reserves as per UNFC categorisation. It is a matter of great concern that with rapid expansion in the steel manufacturing capacity, there will be unprecedented demand for iron ore for domestic consumption since it is estimated that by the year 2030, India is likely to produce 300 mt. of steel to meet the ever-growing domestic demand. Besides, India is likely to continue its iron ore export to keep the structural balance in the international market. In such a situation, can India equip itself to meet the surging demand for iron ore and what should be the strategy for the country not only to augment its iron ore resources but also to enhance its reserve base to a respectable level.

Iron ore Reserves and Production in India

Reserves/Resources

Hematite and magnetite are the most significant iron ores in India.

- Hematite, a highly regarded mineral, is found in India's Precambrian Iron Ore Series deposits. It is found in large, laminated, friable, and powdery forms, forming layers of banded iron ore.
- As of 1.4.2020, the total haematite reserves were 24,057 million tonnes, with 25.80% classified as reserves and 74.20% as remaining resources.

- The Eastern Sector holds 79% of the world's haematite ore resources. Odisha (9,409 million tonnes or 39%), Jharkhand (4,710 million tonnes or 20%), Chhattisgarh (4,592 million tonnes or 19%), Karnataka (2,835 million tonnes or 12%), and Goa (1,197 million tonnes or 5%) are home to most haematite deposits and resources.

- Andhra Pradesh, Assam, Bihar, Madhya Pradesh, Maharashtra, Meghalaya, Rajasthan, Telangana, and Uttar Pradesh contain the remaining 5% of the country's haematite resources.

- The Southern Sector has 93% of the world's magnetite ore resources. The five states of Karnataka (7,802 million tonnes or 69.50%), Andhra Pradesh (1,472 million tonnes or 13.10%), Rajasthan (794 million tonnes or 7.10%), Tamil Nadu (528 million tonnes or 4.70%), and Goa (266 million tonnes or 2.30%) comprise 96.70% of India's magnetite reserves and resources.

- The remaining 3.30% of resources are shared by Assam, Bihar, Chhattisgarh, Jharkhand, Kerala, Maharashtra, Meghalaya, Nagaland, Odisha, and Telangana together.

- 11,227 million tonnes of magnetite are estimated to be in reserves; 202 million tonnes are listed as reserves and 11,024 million tonnes are listed as remaining resources.

- Coal washery grades account for 80%, Unclassified, Not-known, and Metallurgical grade resources for 20%. The proportions of Foundry grades and Others' resources constitute a meagre share.

Reserves/Resources of Iron Ore (Hematite) as of 1.4.2020

States	Reserves	Remaining Resources	Total Resources
Andhra Pradesh	44744	350872	395616
Assam		30890	30890
Bihar		55	55
Chhattisgarh	1593732	2998379	4592111
Goa	117235	1080322	1197557
Jharkhand	534677	4175469	4710146
Karnataka	1043212	1792781	2835992
Madhya Pradesh	54129	302870	356999
Maharashtra	15241	286304	301544
Meghalaya		225	225
Odisha	2798749	6610582	9409331
Rajasthan	7314	28166	35480
Telangana		105627	105627
Uttar Pradesh		86330	86330

Source: LSI Research Calculations based on IMBY Data

Reserves/Resources of Iron Ore (Magnetite) as of 1.4.2020

States	Reserves	Remaining Resources	Total Resources
Andhra Pradesh	-	1472383	1472383
Assam	-	15380	15380
Bihar	-	49439	49439
Chhattisgarh	75876	30045	105921
Goa	4990	261345	266336
Jharkhand	-	10667	10667
Karnataka	318	7801853	7802171
Kerala	-	83435	83435
Maharashtra	578	1210	1788
Meghalaya	-	3380	3380
Nagaland	-	5280	5280
Odisha	-	242	242
Rajasthan	121060	673866	794926
Tamil Nadu	-	528901	528901
Telangana	-	87366	87366

Source: LSI Research Calculations based on IMBY Data

Demand and Supply Scenario in India

The demand for Iron ore depends mainly on the consumption of ore by the iron and steel industry, as 99% of the iron ore produced in the country is consumed by the steel industry. It is of utmost importance to consider the past trend in demand and supply of iron ore while planning for the strategy of future growth and expansion of the steel industry in the country.

There is adequate supply of iron ore over time, to meet the growing demand. Production of iron ore, comprising of lumps, fines, and concentrates, increased by 23.86% between 2020 and 2022 to 253.97 million tonnes. There were 245 reporting mines created in all, 202 of them in the public sectors and 43 in the private sectors. Of the overall production, the Private Sector contributed 60.70% and the Public Sector 39.30%. Out of 43 public sector mines 22 of them produced more than a million tons per year, or 97.59% of the total. 62.06% of the entire production came from non-captive mines, while 37.94% came from captive mines. Iron ore lumps made up 28.69% of the total output, Chhattisgarh is the top producer of iron ore-lumps with 41.31 million tonnes produced, or 16.27% of the total, Karnataka comes in second with 40.33 million tonnes and Jharkhand with 24.72 million tonnes. Maharashtra, Rajasthan, Andhra Pradesh, and Madhya Pradesh are the top four producers with 10.90 million tons, or 4.29% of the overall production of iron ore. There was inconsistency in iron ore production by Goa mainly due to the legal issues. The table below depicts state-wise iron production.

State wise Production of Iron ore from 2013-14 to 2021-22 (in '000 tonnes)

State	2013-14	2014-15	2015-16	2016-17	2017-18	2018-19	2019-20	2020-21	2021-22	CAGR
Chhattisgarh	29250	29388	26718	33285	34418	34945	34728	36839	41313	3.91%
Goa	0	0	1794	9170	10279	0	0	1003	0	-13.53%
Jharkhand	22624	19237	19198	21224	20169	23433	25015	21434	24728	0.99%
Karnataka	18684	20205	25036	26483	28691	29796	31392	34500	40332	8.93%
Odisha	76188	52022	79856	99617	102186	113055	146637	104485	136696	6.71%
Others	5437	8469	5506	4805	5683	5217	6311	6780	10904	8.04%
All India	152183	129321	158108	194584	201426	206446	244083	205041	253973	5.86%

Source: LSI Research Calculations based on IMBY Data

In 2021-22 the apparent consumption of iron ore was about 236 million tonnes, as against 174 million tonnes in the previous year. Despite the highly fluctuating growth rates, the demand has registered 8.21% CAGR for 10 years from FY12 to FY22 as against the 6.56% growth rate of supply. There was an unusual growth rate both in demand and supply during the year 2018-19 which is attributable to the low base in 2015-16 and sudden surge in demand supply, during 2018-19. Iron-ore market like any other commodity market is subjected to cycles and super-cycles in the economy. The expansion and contraction of the iron-ore being the intermediate input completely depends on the dynamics of the respective iron & steel market. Iron-ore experiences a derived demand completely led by the sectoral interlinkage of iron & steel sector with other sectors in the economy, especially by construction sector, automobile sector and infrastructure. The growth of iron and steel market is positively correlated with the amplitude of economic growth both domestically and globally, nevertheless Indian iron and steel market faces steep competition from the foreign market in the form of import of cheap steel, and in the export market with other foreign competitors relatively lower steel price. Historically demand-side for iron ore has been relatively much volatile compared to the supply-side, and the volatility in demand has accounted with fluctuations in the domestic steel production, whereas the production of iron ore has been stable due to its export market opportunities.

Understanding Market Dynamics of Iron-ore: Econometric Modelling Approach

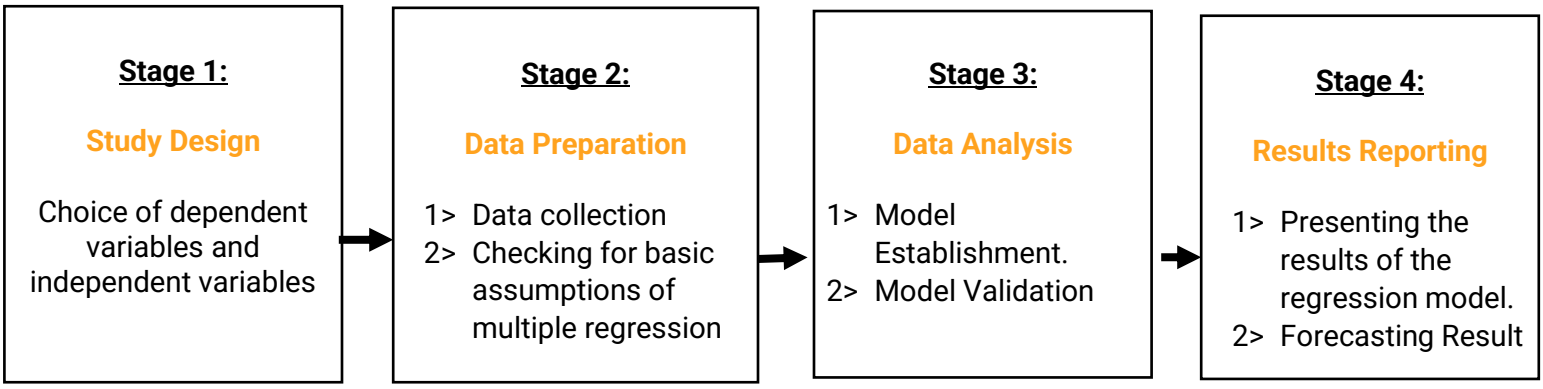
In National Steel Policy, 2017, by Government of India it has been envisioned that the domestic steel industry can be propelled in a better direction with appropriate policy support. The policy is committed to achieve industry efficiency by optimally utilising the resources and creating environment for promoting domestic steel. Since India is already the second largest steel producer in the world, the country's steel sector is all set to create a global benchmark in terms of quality, standards, and technology. The policy aims to create capacity of 300 million tonnes of crude steel capacity by 2030. New Steel Policy seeks to increase per capita steel consumption to the level of 160 Kgs by 2030 from existing level of around 60 Kg. Nonetheless achieving the desired capacity calls for extensive mobilisation of natural resources, finances, manpower and infrastructure including land. Among these iron ore being the backbone of the steel making process needs to be streamlined in terms of deeper exploration and supply.

Methodology

The current data-driven study is unique in detailing specifications by incorporating iron-ore market dynamics along with other influencing factors, into the demand–supply framework to understand the market scenario of iron-ore. The study uses the annual the data from 2012 to 2022 of iron-ore production and consumption and their respective influencing parameters corresponding to the same period. A time series exploration is performed by means of regression analysis to understand the mean effect of the change in influencing variable on the dependent variables i.e., iron-ore production and iron-ore consumption. The effect would be obtained in the form of estimates. In order to work with a balanced data-set (data-set for which data are available for all variables for each time point) the empirical exercise is limited within the mentioned timeframe. Following the regression analysis, a forecasting exercise (2023 to 2035) for iron-ore production and consumption is performed, conditioned upon the behaviour of its influencing variable.

The data generating process of all the time-series variables in the production and consumption models are found to be stochastic in nature, and for this reason, the respective models has been estimated following all the necessary methodology of time-series regression. Initially for all the variables, the values were found to be non-stationary

i.e., trend of the variables are time variant and therefore the all the series has been made stationary to obtain unbiased and consistent estimates. The statistical test confirmed that there is presence of autoregressive and moving averages in the series. The necessary time series econometric model- maximum likelihood estimation (ARFIMA) has been used in the respective exercise and consequently information of the same has been used to do the out of sample forecast for the production and consumption of the iron-ore in India.



Note: *Regression analysis includes many techniques for modelling and analysing several variables, when the focus is on the relationship between a dependent variable and one or more independent variables. More specifically, regression analysis helps one understand how the typical value of the dependent variable changes when any one of the independent variables is varied, while the other independent variables are held fixed.*

Production-Side Model of Iron-Ore in India

This section deals with the analytical part of the empirical model of production of iron-ore. We develop an econometric approach to understand in what manner the significant parameters are influencing the production of iron-ore and hence the supply. During the journey of economic growth of India, iron and steel has a pivotal role and so thus iron-ore, and in the entire process sectoral-interlinkage plays an important part maintaining a steady growth process and balancing demand-supply situation.

Assuming a standard production function with respect to iron-ore production, we incorporate demand shocks into the model, which is endogenous into the production process. The aggregate output of iron-ore is Y(t).

Y(t) = f (Iron-Ore Consumption(t), Iron-Ore Inventory(t), Iron-Ore Reserve(t), OPEX(t), Import of Iron-Ore(t), Export of Iron-Ore(t), Domestic Price of Iron-Ore(t) Export Price Iron-Ore(t) Index of Industrial Production(t), Demand Shock(t)).

The objective of the study is to estimate the above-mentioned functional relationship by means of Multiple Linear Regression Model (MLRM)- an econometric approach, to understand the impact of the influencing variables on the domestic iron-ore production. The study will provide key insights related to the sector for all the stakeholders: policymakers, business world and to the investors, on specific points that are responsible for stimulating the domestic iron-ore production side.

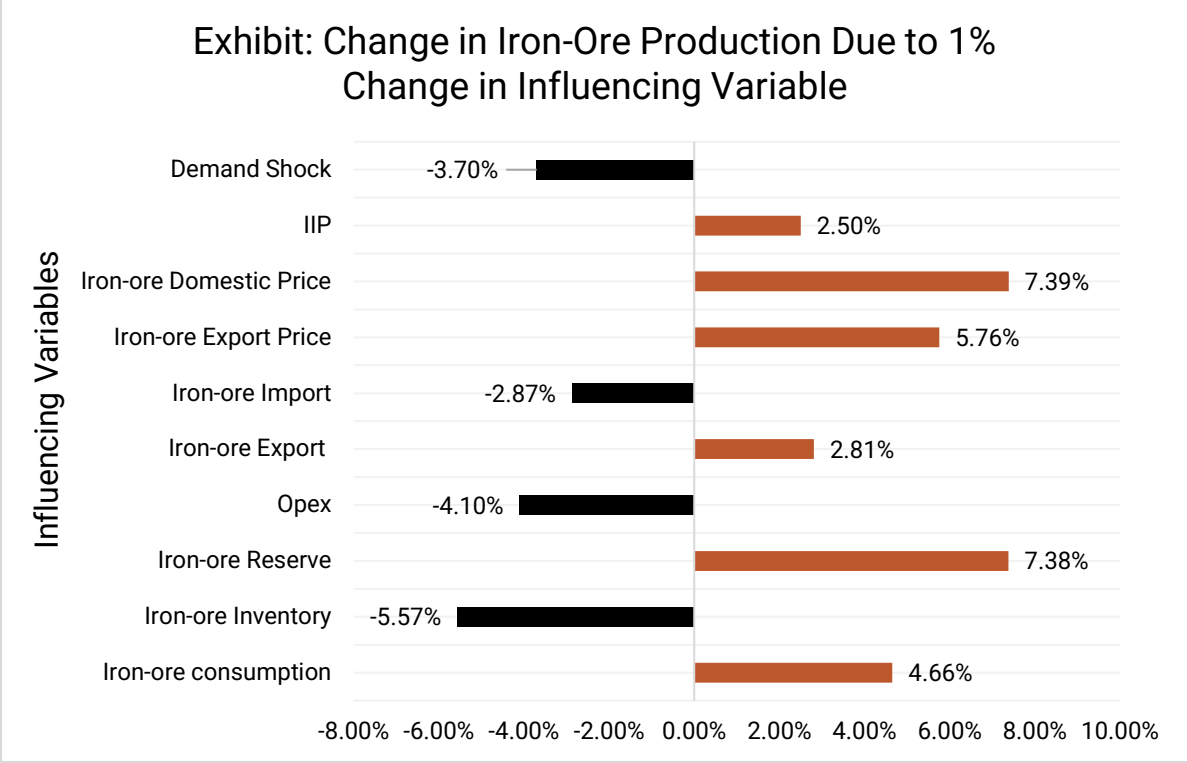
Description of Influencing Variable and Data: Iron-Ore Production

The functional relationship mentioned above, contains the important determinants based on which the production of iron-ore would depend and consequently supply. The dimension considered in the equation factors in demand of iron ore along with price of the same in domestic and foreign market, the model also accounts for the international trade and cost parameters. The model is comprehensive to encapsulate all the policy changes and shocks in market domestically and globally by means of the variables accounted for. To develop the production side model (aka supply-side) demand factors incorporated in the model are: **'Iron-Ore consumption'** in lag period is considered as a crucial determinant for production in the current year because it is rational to expect the demand for iron-ore from observing its previous periods trend, and following that optimal iron-ore production can be decided upon, and since iron-ore demand is of derived demand from the iron & steel sector, which depends on the relative demand strength of the industry in the sectoral interlinkage, and '**IIP'** is a good approximation for the overall sectoral growth of the economy; and the foreign demand of iron-ore is accounted by the '**export demand'**. **'Inventory'** accumulation adds on to the overhead cost, and is a negative factor, hence given the expected iron-ore demand, production amount in the current period can only be decided upon after accounting for the inventory. Another important variable is the endowment of the resource i.e., **'iron-ore reserve'** is considered in the model, which stands as the initial physical endowment of production. Since the expansion and new investments in steel industry mainly depends on the availability and uninterrupted supply of iron ore resources, it is utmost importance to reassure the investors of providing the same. Depletion of the iron-ore reserve is an important yard

stick to decide for the quantity of ore to be extracted because of its non-renewable characteristics and hence production optimization of iron-ore given the resource constraint is performed every time. Price of the iron-ore is the most significant market clearing instrument and to account for that '**domestic & export price of iron-ore'** is considered. Both the price variables are hypothesised to have positive relationship with the production. To account for the cost of mining iron-ore **OPEX** is considered in the model '**Demand Shock'** an endogenous parameter is considered in the production model in addition to all the exogenous parameters. Demand shocks arise from uncertainty from the uncertainty in market demand of iron and steel, and scrap being the close substitute of iron ore also have cross demand implications in the form of shocks.

Empirical Result and Analysis

This section deals with the reporting and analysis of the results based on the statistical significance of the regression model of production of iron ore. (All the variables are significant at 5% level).



Source: LSI Research Calculations based on data from IMBY, CMIE

Set of Positively Influencing Variable of Iron-Ore Production

- We hypothesised that the variable **Iron-Ore Consumption** is going to positively affect the dependent variable Iron-ore production. And the regression model analysis conforms the hypothesis i.e., a positive change in the iron-ore consumption in the previous periods will be leading to an increase in the iron-ore production in the current period, since the current period iron-ore production is decided by forming an expectation on last period consumption. While setting the expectation over the demand if any systematic mistake is occurred then that respective expectational error would be internalized in the next period coal demand expectation process, and in due course this rational expectation process will ultimately lead towards the optimal iron-ore production based on demand in the long run. To account for the systematic mistake in short run we incorporate error correction model of timeseries econometrics. Error correction model confirms that though in short run there is disequilibrium but in long run the model indicates to be in equilibrium.

- **Index of Industrial Production (IIP)** is considered in the model to account for the sectoral growth in terms of income and market size. The indicator is hypothesised to have a positive relationship with the production of iron-ore, and the estimated model confirms the same. the result is implying with the overall growth of IIP there is an increasing demand of iron & steel and followingly demand of domestic iron ore is increasing given the backward linkage effect. Nevertheless, in recent times domestically iron and steel sector are experiencing sluggishness in demand in the face of steep competition from import of cheap price steel, otherwise the impact magnitude of IIP is expected to be more on the production of iron-ore.

- **Export demand of iron ore** is having a directly proportional relationship with production of iron-ore. India is having a rich deposit of iron ore and continues its iron ore export to keep the structural balance in the international market.

- **Iron-Ore reserve** plays an important factor in the iron-ore production process. From the empirical model it is observed that increase iron-ore reserve is positively affecting the production of the same, since iron-ore being a non-renewable resource must be extracted judiciously. Growth of iron-ore reserve happens organically but with a very slow pace. But iron ore is required steel production process constantly driving the

economic growth with high positive sectoral interlinkage effect. Hence iron-ore reserve is going to positively influence the iron-ore production. Presently, India being one of the leading producers of iron ore in the world would like to consolidate its position through sustained exploration of iron ore. Since the expansion and new investments in steel industry mainly depends on the availability and uninterrupted supply of iron ore resources, it is utmost important to reassure the investors of providing the same.

- **Domestic and export price of iron-ore** is having a positive relationship with the production of iron ore following the incentive to supply more at high price. IIP is an indicator used to measure the economic level of a country or region and when economic situation is good, downstream industries such as the construction industry and the automobile machinery industry will have good development, which can increase the demand for iron ore and thus increase iron ore prices. Therefore, the above two factors can be seen as specific macroeconomic manifestations that affect iron ore production. This phenomenon may be caused by the lagged effect of macroeconomic indicators on iron ore prices and consequently in the production of iron-ore in the next period. Therefore, we consider these both domestic and international price in predicting production level of iron-ore. Macroeconomics plays an invaluable role in commodity trading and is a very important indicator that affects commodity prices and production. We can easily understand that when the economic situation is good, downstream industries such as the construction industry and the automobile machinery industry will have good development, which can increase the demand for iron ore and thus increase price, implying higher production, but iron-ore production is constrained by its proved reserve.

Set of Negatively Influencing Variable of Iron-Ore Production

- **Iron ore import** is negatively affecting the domestic production but not that too significantly. Iron import in India happens for certain grades which are not having high deposit or further exploration is required for mining them.

- **OPEX** is hypothesised to be positively affecting the iron-ore production, but the result from the estimated regression model shows the other way round, i.e., change in capital employed has negative relation with the dependent variable. The result is

implying that marginal productivity of capital has become negative and the operation of coal mining is not enjoying the return to scale. India currently has abundant iron-ore reserves and is not only self-sufficient but also in a position to export surplus iron ore with judicious planning. Contrarily, there has been a concern on the non-availability of desired quality and quantity of iron ore on a sustained basis. Therefore, it might be possible that the extraction cost of the industry is relatively higher compare to the high quality of grade obtained. To increase the efficiency of the production system augmentation of iron-ore reserves has been to be there and moreover deeper exploration of mines for better quality of iron-ore is required.

- **Demand shock** in the estimated model is found to be affecting the production of iron-ore negatively. Firstly, it implies that there is fall in demand for domestic steel in recent times because relatively low-price steel is being imported for the domestic use. Secondly, Recycling of scrap steel has a material impact on the demand for iron ore hence production.

- **Iron-ore inventory** is hypothesised to have a negative relationship with iron-ore production and the result of the regression model has been in conformity with hypothesis. Accumulation of inventory is perceived negatively in the production decision by the iron-ore mines. Principle decision rule for the iron-ore will be to first clear off the existing stock before extraction of fresh ore from the mines.

Consumption-Side Model of Iron-Ore in India

This section deals with the analytical part of the empirical model of iron-ore consumption in India. Here a similar sort of analysis like the iron-ore production will be performed to understand the market scenario from the demand side perspective of iron-ore in India is a dominant source of input for steel making in India, but currently there is a shift from blast-furnace to electric-arc furnace where recycling of scrap steel has increased its share in steel making as a substitute of iron-ore. But There is no denial of the fact that the Iron Ores are the backbone of Indian steel industry and hence the consequent economic development of the country. According to the India Steel Policy, 2017 the targeted steel production by 2030 is 300mt. Hence, it is of utmost importance to understand the crucial parameters on which the demand for iron ore depends so that relevant production decisions (including planning and streamlining the logistical

arrangement for supplying iron ore) can be taken promptly to supply the optimal amount of iron ore in due time.

We assume a standard iron-ore consumption function and we incorporate supply shocks into the model, which is endogenous into the production process. The aggregate iron-ore consumption is represented as C(t):
C(t) = f (Steel Consumption(t), Scrap-use of Steel(t), Domestic Price of Iron-Ore(t), Steel Scrap Price(t), Capital-Output-ratio(t), Interest Rate(t), Supply Shock(t)).

By means of a Multiple Linear Regression Model (MLRM)- an Econometric approach here in this study we try to estimate the above functional relationship for understanding the impact of the change in influencing variable on the iron-ore demand in terms of magnitude and direction.

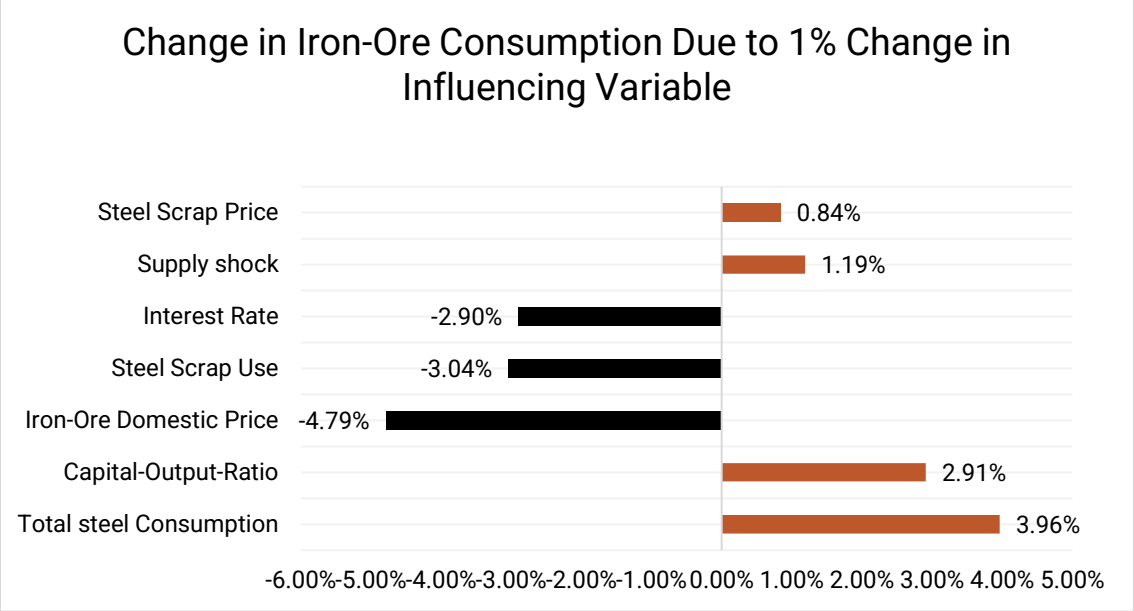
Description of Influencing Variable and Data: Iron-Ore Consumption

Iron-ore consumption model is founded based on the demand of its downstream industries and forward-linkage market. The consumption model of iron ore is estimated based on the macroeconomic scenarios condensed into the explanatory variables considered in the model. The consumption model also accounts for the technological shift in steel making process. Since 99% of iron ore is going to be directly used in the steel production, '**consumption of steel'** in the economy is the most predominant factor determining the consumption of iron-ore, and ***demand for iron-ore*** is an ***implicit function of demand for steel***. Virtually all steel is produced by one of two basic technologies: blast furnace iron making, which uses iron ore as feedstock, or the electric arc furnace (EAF), which primarily uses steel scrap as feedstock, therefore due to the technological change in the steel making process there is a substitution effect on demand or iron-ore from **'scrap-use of steel'**- considered in the model to incorporate the dynamic trend (possibly due to aging blast furnaces or declining iron ore quality). '**Domestic price of iron-ore'** in real terms is considered in the model by deflating the weighted average price of both lump and fines by WPI of iron ore in India. **Scrap prices** considered in the model are assumed to be directly related to electric arc furnace production of steel and scrap supply. An important component of scrap supply comes in the form of trimmings generated in the fabrication of goods such as automobiles and consumer durables. **'Capital output ratio'** in the economy is a crucial parameter determining the demand for

steel. The nature of Capital-output-ratio in the economy will contain the overall economic growth entailing the marginal productivity of capital. Steel value chain in the economy is dependent on the rate of urbanisation and industrialisation, and during the different stages of development of an economy per-capita steel use changes- quantity and quality of steel demand; because steel quality for infrastructure and EPC products would be very different from the steel to be used in the final good of the consumer market. Based on the **'interest rate'** of an economy its' rate of investment to GDP will depend which will further determine the overall IIP in the economy and consequently the demand for steel. **'Supply shock'** is considered in the model to account for the iron-ore price fluctuations or any other form of uncertainty that could break the supply trend.

Empirical Result and Analysis

This section deals with the reporting and analysis of the results based on the statistical significance of the regression model of consumption of iron ore. (All the variables are significant at 5% level).



Source: LSI Research Calculations based on data from IMBY, CMIE

Set of positively Influencing Variable of Iron-Ore Consumption

- From the estimated regression model **'consumption of steel'** is steel is having positive and significant relationship with consumption of iron-ore. As mentioned earlier demand for iron-ore has direct linkage with the demand for steel. But steel making through blast-furnace process would only demand iron-ore and not the electric-arc furnace. Therefore, demand for iron-ore is mostly can be entailed to the life of blast-furnace based iron & steel plant. In the last decade consumption of steel has experienced a growth of 6.2% CAGR.

- As hypothesised '**capital-output-ratio'** is observed to have positive relationship with consumption of iron-ore. Demand for steel is functional of different stages of development through which the economy undergoes. In the early stage of development steel is mostly use for the purpose of building infrastructure, in the process of industrialisation and urbanisation, but with the advent attaining a level of economic maturity the composition of usage of steel shifts towards catering the consumer durables and retail demand. India being a high valued middle-income economy has dual nature of both the cohorts comprising high industrialisation and urbanisation along with large infrastructural development requirement resulting in high per-capita demand of steel domestically, and moreover to gain its position in the global value chain India is taking exposure in the foreign market by exporting high value manufacturing good, consequently towering demand of domestic steel. So, iron-ore has been undoubtedly having pivotal role in nation building.

- **'Scrap price of steel'** is having a positive relationship with the iron-ore demand implying a positive cross price effect. But the impact is not that significant since scrap steel is primary input of electric arc furnace only and steel plants engaged with blast furnace route of steel making cannot use scrap steel. So, the use of scrap steel is limited by technology.

- **'Supply shock'** is observed to have positive relationship with the iron-ore consumption. Supply shock which is assumed in the model to be mostly arising from change in price of iron-ore is found to be oscillating in nature, nonetheless the price change per unit of iron is not having any negative impact on its consumption is implying the inelastic nature of iron-ore demand.

Set of Negatively Influencing Variable of Iron-Ore Consumption

- In line with the expectation, **'interest rate'** is having a negative relationship with iron-ore consumption. The rationale for having such relationship is: with higher interest rate in the economy is going to cause lower rate of investment and hance per-capita GDP will decline and consequently lesser per-capita steel will be demanded. During the observed period in the analysis RBI has always been quiet dynamic in controlling the inflation by means of changing interest rate according to the need to stabilise the economic fluctuations which has resulted in lowering of the rate-of-investment-to-GDP especially in post covid era. But however, the for the last few quarters December,2023 the scenario has changed as RBI is holding on to the interest rate and hence investment is expected to take an upswing in long to medium term resulting in more demand for steel.

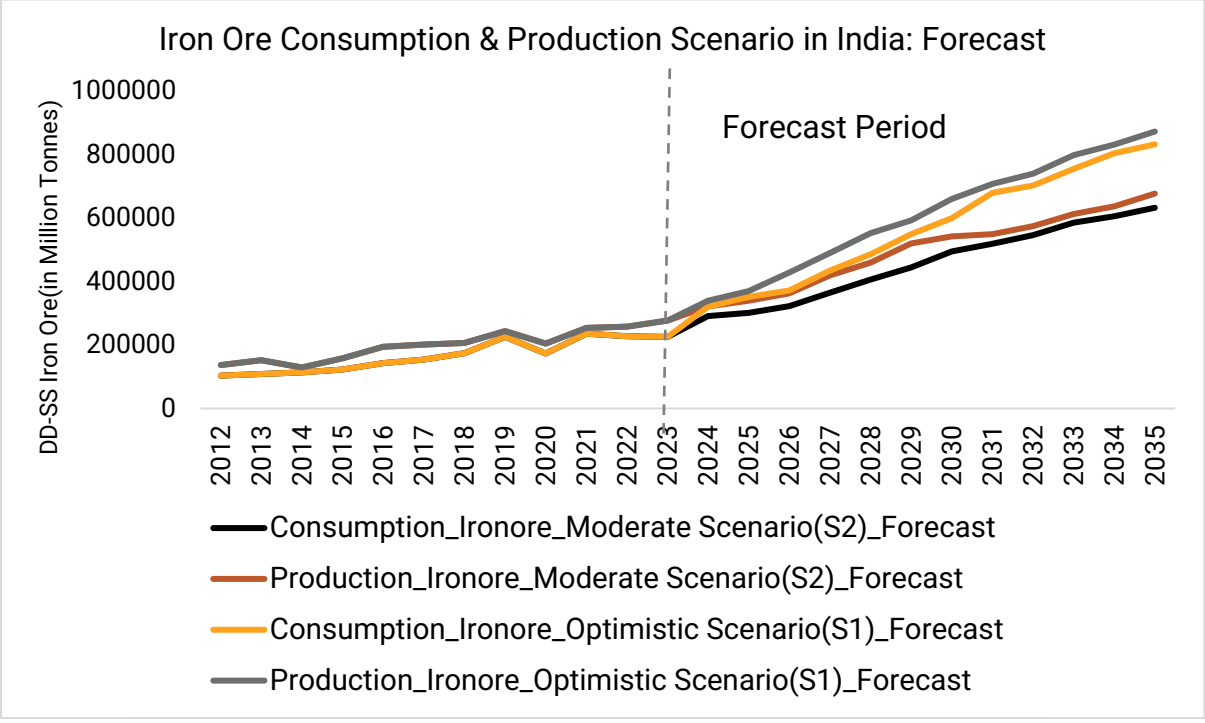
- Own price effect is captured by '**iron-ore domestic price'** having negative influence on the dependent variable iron-ore consumption. But the estimated price impact is not significantly affecting the iron-ore demand, implying the nature of iron-ore demand to be inelastic. From the inelastic demand for iron-ore, it is deducible that in India blast-furnace is still the dominant form steel making process where iron-ore is used as the feedstock.

- **'Scrap steel use'** is a close substitute for iron ore. Hence its price is also included in the demand function. Overall, in the iron & steel industry there is a shift from the blast-furnace route of steelmaking to electric-arc-furnace route where steel scrap can be used. As hypothesised scrap steel is going to negatively affect the iron-ore demand in the overall iron & steel, and with advent of green steel mission steel plants are shifting towards technology of electric-arc-furnace, where they can use scrap steel as the main input and sponge-iron if required. Therefore, in India steel makers are shifting towards a convex type of production technology where there is a scope of competitiveness among scrap-steel and iron-ore. In coming days it is expected that use of scrap steel is going to be more in use of steel making, because with target of reduction in carbon emission iron and steel making India is shifting towards electric-arc-furnace method, and moreover since the quality of scrap steel is already known ex-ante therefore uncertainty component regarding the steel quality is relatively less while using the recycled steel compared to iron-ore, hence the quality of steel can be more optimally controlled.

Forecast of Domestic Iron-Ore Production and Consumption: A Scenario Analysis

Estimated time series regression model result of iron-ore production and consumption has been utilised further to conditional forecast of the domestic iron-ore production and consumption. Statistical test has been performed to verify the long run equilibrium relationship among the set independent/influencing variables and the dependent variables i.e., iron-ore production and iron-ore consumption. The long run relationship is established since the set of maximum number of the influencing variables are cointegrated with the iron-ore production and consumption respectively. After confirming the long run equilibrium relationship, the dynamic forecasting of the iron-ore production and consumption has been done for the period of 2023-2035.

While forecasting the iron-ore production two scenarios have been considered – an Optimistic Scenario (S1) and a moderate scenario (S2). Two scenarios have been considered based on past trend of production and consumption, and incorporating shocks that has entered the system due to several factors such as domestic and international demand, government policies, timely investments, commodity's growth, market fluctuations due to unforeseen situations etc.



Source: LSI Research Calculations based on data from IMBY, CMIE

- **Optimistic Scenario (S1):** states the situation where there will be towering infrastructural expansion to maintain high economic growth, and correspondingly the steel demand. This situation is based on the postulates of the steel manufacturing target set as per National Steel Policy in India As per optimistic scenario the Indian iron ore mine companies should gear up to have a capacity to produce around 661 m.t. of iron ore to fulfil the projected target of 300 m.t. of steel production and provision for substantial iron ore for export by 2030, and going ahead by 2035 the iron ore production should be capable enough to produce 873 m.t against the consumption of 832m.t. The scenario is conditioned upon high per-capita demand of steel and high export of heavy manufacturing good under the programme of 'Make in India'. The CAGR of iron ore production for S1 is 9.03% and iron-ore consumption is 10.55%. This projected target is achievable provided the government facilitates to attract necessary investments both from public and private sector companies in iron ore mining industry by formulating investor-friendly policies.

- **Moderate Scenario(S2):** the moderate scenario is considered based certain postulates: Firstly, by assuming a shift in the production process of steel making where the domestic demand for iron ore would be substantially reduced by 2030, since government's Steel Scrap Recycling Policy (MoS, 2019) envisages that about 35-40% of steel production in India will be through secondary route i.e., utilisation of steel scrap by Electric Arc Furnaces (EAF) and Induction Furnaces (IF). This amounts to saving of 132 m.t. of iron ore per annum, as the use of every ton of scrap shall save 1.1 ton of iron ore, besides saving 630 kg of coking coal and 55 kg of limestone, which will indeed be a very positive development in iron and steel industry of the nation; Secondly, after 2030 in the moderate scenario there is a consolidation of demand of steel as the Indian economy attains a level of growth, and alongside many foreign economies would also shift towards electric arc furnace method due to which there will be less export demand of iron ore. Similarly, there is a possibility of satiation in steel demand from the foreign economy till they reach the next level of growth trajectory. According to moderate scenario by 2035 the production of iron-ore 677 m.t. against the consumption of 632 m.t. The CAGR of iron-ore production for S2 is 6.87% and iron-ore consumption is 8.24%.

Conclusion and Way Forward

India has an abundance of resources for iron ore, with a high Fe concentration. The two most important iron ores at the moment are magnetite and hematite, whereas iron hydroxides with low Fe contents, such as goethite and limonite, may be valuable in the future. India's large and plentiful iron ore reserves serve as the ideal starting point for the steel industry in India to flourish. As previously mentioned, the Indian steel sector is ready for a quantum leap in the upcoming years to satisfy the steadily rising domestic steel demand in the nation. Given the abundance of iron resources available, it would not be insurmountable to manufacture around 600 metric tons of iron-ore by 2030 to satisfy the demand of the steel industry, given appropriate policy in place.

Looking at the technological advancement in steel manufacturing through consumption of iron scrap, there would be huge scope to conserve iron ore resources and utilise the same either to enhance the steel production or to divert the surplus ore for export.
The government should appropriately handle the problems associated with exploration and mining while creating new rules and changing the ones that already exist, considering global experiences that more money was invested in the mining industry, particularly in exploration will increase the resources and reserves already in place. Despite quick rise in the nation's need for iron ore, the country will still have a lot of hematite iron ore below 55 per cent of iron (Fe), not accounted for currently. Although these materials are now somewhat expensive, they are not to be disregarded.

To achieve the ambitious goal of producing 300 million tons of steel by 2030, three key issues must be given careful thought, namely:

(i) starting new projects on iron ore prospecting and exploration in the nation's brown fields;
(ii) upgrading the remaining resources to reserve grade by probing deeper through deeper exploration in the green fields; and
(iii) streamlining and accelerating the iron ore block auction process to foster a friendly environment for investors' timely investment to meet the production target. Considering the significant financial outlay, public sectors, or public-private partnerships (PPPs) can accomplish the difficult task.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