Response to Reviewers' Comments

Revision 1

The paper is too description. It needs shortening.

The paper has been shortened, specifically by omitting four paragraphs from the introduction section.

Introduction: The 'Introduction' section fails to introduce the paper. It is rather an introduction to the steel manufacturing sector of India. Please convert it to the introduction to your paper. The introduction sector should have introduced the remaining sections. No reference is cited in the introduction section.

We have added one paragraph (on page 3) at the end of the first section 'Indian Steel Industry Structure' that introduces the remaining sections of the paper. Reference from the World Steel Association has been cited in the first paragraph.

Steel industry structure: The section is unnecessarily too enlarged. These two sections should be made one. It needs reduction in size and be written in more concise.

The two sections 'Introduction' and 'Steel Industry Structure' have been merged into one after reducing some content. The new section is titled as 'India Steel Industry Structure'.

Table 1 is actually a figure. It can be renamed as 'Figure 1.'

Table 1 is renamed as figure1.

Transport Flows: Please give proper reference of the Ministry of Steel Annual Report with page, year and place of publication.

Incorporated

Transport trend: Page 5: authors' discussion is it formal or informal? Was there any questionnaire or protocol for the discussion? When and how many etc. information must be specific.

We assume that the reviewer is mentioning about page 7 where authors discussion is mentioned. We like to mention that all discussions were formal to seek answers to specific questions (There is no questionnaire or protocol for the discussion.)

Table 2 author's analysis is based what document (derived from)?

The Section 'Transport Trends' describes the methodology used by authors for deriving table 2 (now renamed as table 1)

Importance of steel sector for railways: Page 8: 'iron ore earned the maximum revenue ----m' can be rewritten as 'the maximum revenue earning was from iron ore (Rs 28,813m) followed by ---.'

Incorporated

Current issues in rail transport: The bullet point 'Bypasses— ------- four hours' is not very clear. Page 10: use proper reference in the text e.g. Raghuram and Bastian, 2008. The bullet point 'There are delays---- as required (RINL)' is not clear. Page 11: the bullet point 'BOXN wagon----(TATA)' is not clear.

Sentences are reframed to make the content clearer.

The way forward: Table 6 and 7: author's analysis is based what document?

For table 6 (now renamed as table 5), authors have taken the existing rail share from table 2 and projected to a desirable rail share in round figures in the realm of feasibility. Future loading in million tons was estimated in table 1. Based on the desirable rail share and future loadings, authors have projected the possible loading for railways for year 2011-12 and 2019-20.

In many places within a closed bracket some terminologies are such as RINL, TATA, SAIL. It is not clear whether they are references or not. If they are references, then the referencing should be done properly.

RINL, TATA and SAIL are the steel plants. In section 'Current Issues in Rail Transport,' these were mentioned in closed brackets as references for pointing out that particular issue as a customer of Indian Railways. However, we have now removed these references for avoiding any confusion.

Revision 2

Abstract: it would be useful to include some basic details about the proposed strategies towards the end of the Abstract.

Added at the end of the abstract.

Introduction: some comment on the likelihood of linear growth in steel production/consumption would be helpful, dealing with the issue of whether there is likely to be market saturation at some point.

Comment has been added at the end of paragraph two (on page 2).

Methodology: it would be useful to have a separate section where the study's research methodology is clearly elaborated

A paragraph describing the methodology has been added at the end of the first section (on page 3).

Table 1: the heading should include the year for which the data apply

Incorporated

In general: some terminology needs explanation (e.g. "on the anvil", "ghat section") and acronyms need to be spelled out or explained (e.g. wagon types)

Terms have been explained. There is also a glossary added at the end of the paper to explain all acronyms including wagon types.

Table 5: what are the units in the table?

The numbers represent a class based on Indian Railways price structure. We have included a few lines explaining this in the first paragraph on page 13 under 'Tariff Structure.'

Exhibit 7: some additional interpretation of the data and model is required

Content added in the last paragraph on page 15 under 'Infrastructure'.

Exhibit 8b: some discussion about the practicalities of mixing different commodities is required e.g. in terms of synergies in origins and destinations of commodity flows, handling requirements at terminals)

Example included in the last paragraph on page 17.

Conclusions: a clear concluding section is required; at present, the paper tails off without being clear about the key findings.

The last section have been made as a concluding section.

HOW CAN INDIAN RAILWAYS SERVICE THE STEEL SECTOR BETTER?

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ABSTRACT

The focus of this paper is on how Indian Railways can service the steel sector better. The steel sector is a core sector, with railways playing a critical role in its logistics. The paper examines the changing industry structure and brings to light the increased need for transportation. Traditionally, crude and finished steel making was done in the same location by big producers having integrated plants. Now the industry has a large number of producers who primarily focus on crude steel making or finished steel making, necessitating the need for transporting crude steel to the finished steel makers. Even within finished steel making, there could be levels of value addition where the output of one finished steel maker could become the input for another.

This has implications for the transporters including Indian Railways in formulating their strategies. Further, based on the growth projections of the steel sector and a possible increased share of rail transport, Indian Railways need to strategize for a six fold increase in traffic. This could be upto 1 billion tons of originating traffic by 2019-20. The paper examines the current issues in rail transport for the steel sector and proposes strategies under the dimensions of infrastructure, technology and systems. These include assessment of origin-destination flows of steel and raw material, thrust towards increased axle loading of wagons, improvement in wagon design, leveraging containerized movement of finished steel, use of advanced technologies in tracking wagon and rake movements, improved supply chain coordination with customers and suppliers, and utilizing empty spaces in steel carrying wagons.

Keywords: Indian Railways, Steel Industry, Rail Transport, Logistics

INDIAN STEEL INDUSTRY STRUCTURE

The steel sector in India has been growing at a compounded annual growth rate (CAGR) of 11.6% for crude steel production during 2003-08. This is above the international CAGR of 6.5%. At a production of 55mt of crude steel during the calendar year 2008, India was the 5th largest steel producer in the world, behind China, Japan, USA and Russia [WSA, 2009]. India accounted for about 4 per cent of the world's total production in 2008.

India is the fifth-largest consumer of steel in the world. Demand for steel in India is likely to grow at around 12% against the global average of 5-6%. A Credit Suisse Group study states that India's steel consumption will continue to grow by 16% annually till 2012, fuelled by demand for construction projects worth US$ 1 trillion. The scope for raising the total consumption of steel is huge, given that per capita steel consumption was only 46 kg in 2006 – compared to 150 kg across the world, 250 kg in China and 400 kg in developed countries. About 60% of the country's steel production is used by the construction and infrastructure sectors. While a 12% CAGR is projected, in the long run, there is bound to be reduction in growth and saturation but it is expected to be beyond the time considered in this paper.

The steel industry broadly consists of raw material sourcing, crude/liquid steel making, and finished steel making. In the traditional integrated steel plants, the crude and finished steel making was done in the same location. Over time, this has changed. There are a large number of producers who primarily focus on crude steel making and similarly many others who primarily focus on finished steel making. Even within finished steel making, there could be levels of value addition where the output of one 'finished' steel maker could become the input of another.

A form of solidified liquid steel called pig iron is also manufactured by many players. Pig iron is used both as an input for finished steel and sold directly to a large number of small and medium industries who need small quantities of iron.

Slag is an important byproduct of the crude steel making process, constituting about 30% of crude steel output. Traditionally, this was sent to a dump in the steel plant location. Increasingly, it is being used for cement making, sometimes in cement plants in the vicinity and sometimes in captive plants.

The raw material requirements are of three kinds: iron ore, coking coal/coke (high value thermal coal can be used directly in certain processes), and fluxes consisting of limestone and dolomite. With best quality raw material, the requirements would be about 3 times the expected crude steel output. Iron ore would constitute 55%, coking coal/coke about 31%, and fluxes about 14%.

Sometimes iron ore is pre processed to sponge iron in stand alone sponge iron plants and sold as raw material to crude steel makers. While this improves the raw material quality in the traditional process, it is a requirement in many small units which are designed to use the same. India has the largest sponge iron industry in the world. There are two types of sponge iron making: gas based and coal based. While iron ore is the primary solid raw material for gas based sponge iron, iron ore, thermal coal and fluxes constitute the solid raw material for coal based sponge iron. The iron ore requirement for a gas based plant would be about 1.6 times the output. In a coal based plant, the raw material requirement would be 3 times, of which iron ore would constitute 55%, coal 40%, and fluxes 5%.

Other raw material improvement processes like sintering of iron ore and converting coking coal to coke, if required, are done within the premises of a steel plant.

Many steel plants also have captive electricity generating units, since power is a critical input in steel making. These units require thermal coal.

All the above elements of the industry structure have implications for movement of raw material, intermediate products including sponge iron, crude steel, and pig iron, and finished steel products. Figure 1 gives the overall industry structure with the possible movement requirements.

The crude steel manufacturers are classified as ‘main’ producers (RINL, SAIL plants – four large and one small, and Tata Steel), ‘major’ producers (Essar Steel, Ispat Industries, and JSW Steel), and ‘other’ producers (comprising of large number of about 650 mini steel plants based on electric furnaces and energy optimizing furnaces). The finished steel manufacturers are classified as ‘main’ (in the case of SAIL, apart from the five mentioned, there are two more small plants) and ‘major’ as already defined and ‘other’ (cold rolling mills, galvanizing/color coating units, and small to medium sized long and flat product manufacturers, totaling to over 1200 units).

In this context, this paper tries to address the question ‘How Can Indian Railways Service the Steel Sector Better?’ We first estimate the current transport flows of raw materials, intermediate products, and finished steel products within the steel industry, given its changed structure, in the section on ‘Transport Flows.’ Given the transport flows, the section ‘Transport Trends’ estimates the commoditywise transport requirements, including import and exports, for the steel industry in 2011-12 and 2019-20. The section ‘Rail Based Movement’ assesses the possible rail share for the steel industry and attempts to build the commoditywise rail movement requirement. The section ‘Importance of Steel Sector for Railways’ estimates the yield generated by IR through various commodities related to steel industry, primarily to emphasize the importance of the sector. The section ‘Current Issues in Rail Transport’ brings out the issues related to enabling rail transport under the dimensions of infrastructure, technology and systems. The last section ‘Conclusions’ proposes strategies for the IR based on the future projections and current issues.

TRANSPORT FLOWS

The authors have assessed the transport flow numbers in Figure 1, since ready information on location, nature of products, and production is not available.

The production of finished steel was 52.5mt in 2006-07 [MoS, 2008]. Of this, 17.6mt was from the ‘main’, 11.6mt from the ‘major’, and 28.4 from the ‘other’ producers. Amongst the ‘major’ and ‘other’ producers, 5.1mt was interplant internal movement for value added processing. Hence, the net finished steel for movement from the ‘major’ and ‘other’ producers was 34.9mt.

The crude steel and pig iron production was 55.8mt in 2006-07 [MoS, 2008]. Of this, 22.1mt was from the ‘main’, 8.4mt from the ‘major’, and 20.2mt from the ‘other’ producers. Pig iron production was 5.0mt. Of the 22.1mt crude steel from the ‘main’ producers, 17.6mt was the interplant internal movement for finished steel making. We assume that the remaining 4.5mt moved to ‘major’ and ‘other’ producers for finished steel making. This 4.5mt, along with the 28.6mt of ‘major’ and ‘other’ producers, and 1.8mt of pig iron is assumed to have moved to ‘major’ and ‘other’ finished steel producers, for the total requirement of 34.9mt of finished steel output. (An increasing, but insignificant amount of crude steel was exported). Out of the 5.0mt of pig iron produced, we assume that the balance 3.2mt was sold in the market to various downstream industries.

Raw material requirement is estimated at 3 times the crude and pig iron production ie 167.4mt. Of this, 18.3mt, being the total sponge iron industry output, was raw material input. Of the remaining 149.1mt, 55% was iron ore (82.0mt), 31% coal/coke (46.2mt), and 14% fluxes (20.9mt). Of the sponge iron output, 5.2mt was gas based and 13.1mt was coal based. The gas based production required 8.3mt of iron ore (being 1.6 times the output). The coal based production required 39.3mt of raw material. Of this, 55% was iron ore (21.6mt), 40% thermal coal (15.7mt), and 5% fluxes (2.0mt).

The raw material requirement can be restated commoditywise:

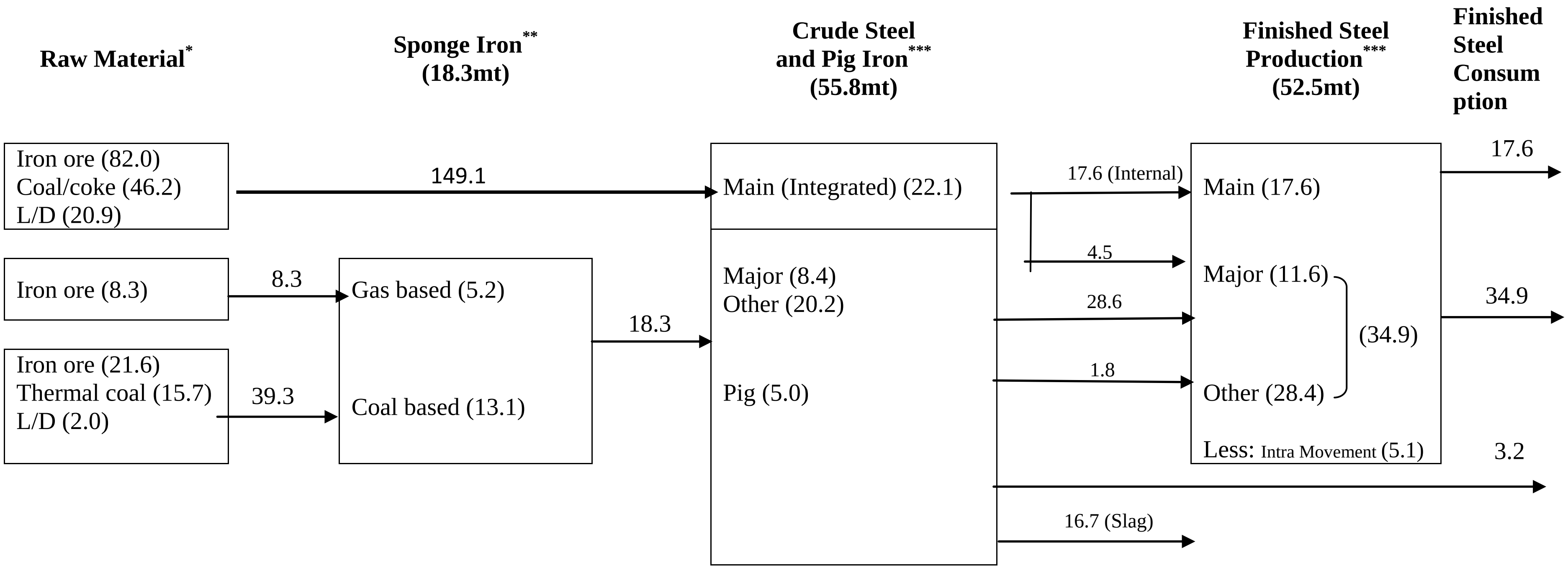
- Iron ore figure of 111.9mt is the total of 82.0mt for crude steel making, 8.3mt for gas based sponge iron making, and 21.6mt for coal based sponge iron making.

- Coal figure of 61.9mt is the total of 46.2mt coking coal/coke for crude steel making, and 15.7mt thermal coal for coal based sponge iron making.

- Fluxes figure of 22.9mt is the total of 20.9mt for crude steel making, and 2.0mt for coal based sponge iron making.

We summarize the above transport requirements for 2006-07 in table 1.

Figure 1
Steel Industry Structure and Transport Flows (2006-07)



Main: SAIL, TATA, and RINL; Major: Essar, Ispat, and JSW Steel; Other: A large number of mini steel plants (based on electric furnaces and energy optimizing furnaces)

*Raw material is estimated to be 3 times the crude and pig iron production.

Iron ore is the major raw material for the gas based plants, which is about 1.6 times the production. Coal based plants require 55% iron ore, 40% thermal coal, and 5% fluxes as raw material. (There are three gas based sponge iron making plants (producing 5.2mt) while 147 coal based plants (producing 13.1mt) in the country)

***direct from Ministry of Steel Annual Report 2006-07

Total material transport: 149.1+8.3+39.3+18.3+4.5+28.6+1.8+17.6+34.9+3.2=305.6 (excludes slag, cement, and coal for power)

[Source: Authors' Analysis]

Some of the numbers could be under estimates like the raw material requirement for crude steel making, since this is dependant on the quality of the raw material. Similarly, figures like sponge iron movement for crude steel making, and crude steel movement for finished steel making could be upper bounds, depending on the level of integration in the newer steel plants.

For a finished steel output of 52.5mt and a direct pig iron sale of 3.2mt during 2006-07, the total movement requirements for the domestic steel industry (excluding thermal coal for captive thermal power plants, slag to cement plants, and cement from captive cement plants) was 305.6mt. This also excludes in plant movements of both crude and finished steel, and slag.

As per the National Steel Policy 2005 (NSP), it is estimated that every ton of 'steel' production involves transportation of 4 tons of material including 3 tons of raw material. As per our estimation, given the current industry structure, the total transportation including intermediate products is at least 5.5 and more likely 6 tons for every ton of finished steel production. However, for a given crude steel plant, the figure of 4 tons per ton of production would be valid. (In reality, based on the authors' experience with some steel plants including JSW Steel [Raghuram and Gangwar, 2009], the actual movement could be upto 4.5, based on raw material quality).

It is quite imperative that both the steel and transport sectors evolve a more rigorous understanding of the industry structure, so that it can be used appropriately for strategizing for the future.

TRANSPORT TRENDS

We project India's crude steel production figure at 100mt in 2011-12, based on a lower bound of 7.3% CAGR (73mt) as per the NSP and an optimistic perspective of the Memorandum of Understanding (MoU) materializing (124mt) [MoS, 2005]. Similarly, for 2019-20, we project the figure at 200mt, based on a 9.1% CAGR from the 100mt in 2011-12. This would seem feasible, since the MoUs indicate a possible capacity of 293mt. Given the current industry structure, we expect the finished steel output to be almost of the same order of the crude steel output, 35% through inplant transfer and 65% through interplant movement. The growth rates have been assumed in the realm of feasibility so that we estimate round numbers, making it easier for subsequent analysis. Precision of forecasting is not important to our analysis.

As per the NSP, while we expect at least 25% of the production (partly as crude steel and partly as finished steel) to be exported, the steel imports are planned not to exceed 5%. For transport assessments, while steel exports are part of the output, we do not explicitly consider steel imports.

At the projected finished steel production and 6 times movement requirement, the total material transport (excluding coal for power plants captive to steel plants, slag to cement plants, and cement from cement plants captive to steel plants) would be 600mt in 2011-12 and 1200mt in 2019-20.

Based on the authors' discussion with the executives of the newer steel plants, we expect almost the entire coking coal/coke to be imported and assume 50% of the thermal coal and 20% of the fluxes to be imported.

Table 1 summarizes the transport requirements (including the port linkages) for the steel industry.

Table 1: **Transport Requirements**

mt

Commodity	**2006-07**	**2011-12**	**2019-20**
Finished steel	**52.5**	**100**	**200**
Domestic	39.4	75	150
Exports	*13.1*	*25*	*50*
Semi-finished and crude steel	38.1	65	130
Sponge iron	18.3	35	70
Raw material	196.5	400	800
Iron ore	111.9	225	450
Coking coal/coke	46.2	100	200
Domestic	-	-	-
Imports	*46.2*	*100*	*200*
Thermal coal	15.7	30	60
Domestic	7.8	15	30
Imports	*7.9*	*15*	*30*
Fluxes	22.9	45	90
Domestic	18.3	35	70
Imports	*4.6*	*10*	*20*
Total	**305.6**	**600**	**1200**
Port linkage (export+import)	***71.8 (13.1+58.7)***	***150 (25+125)***	***300 (50+250)***

[Source: Authors' Analysis]

Given the extent of movement that the growth in the steel industry would require, rail transport would become critical as a primary service provider.

RAIL BASED MOVEMENT

There are difficulties in making an accurate assessment of rail share for the steel industry, due to inherent problems in IR's statistical accounting methods. Aggregate freight data to 'steel plants' is getting documented in the 'Data Book' since 2006-07. Based on discussions with officers in the Railway Board, our sense is that only 'main' steel plants (RINL, SAIL, and Tata Steel) are considered. Non inclusion of the emerging 'major' steel plants (Essar Steel, Ispat Industries, and JSW Steel) is an issue, since there is significant movement to and from these plants. Exhibit 1 brings out our perceived lack of clarity in IR freight data wrt the steel industry.

We attempt to build the main commoditywise rail movement for the steel industry in table 2, based on our understanding of the industry structure (Figure 1) and some assumptions with regard to IR loading.

- Aggregate steel (finished steel, pig iron, and crude steel) figure of 27.0mt is 'Iron & Steel' figure as per the IR Year Book 2006-07.

- Iron ore figure of 77.5mt is the difference of 116.3mt (total iron ore) and 38.8mt (iron ore for exports) as per the IR Year Book 2006-07 and Data Book 2008-09 respectively.

- Coal figure of 50.9mt has been derived based on some assumptions. We assume that the movement of 25.3mt (55% of 46.2mt, which is the share of 'main' and 'major' producers) coking coal/coke to 'main' and 'major' producers is done entirely via rail. Of the remaining 20.9mt to 'other' steel plants and 15.7mt to sponge iron plants, 70% (25.6mt) is estimated as moving via rail from mines, but possibly to intermediate merchant locations and then by road to the respective plants. The remaining 30% would be direct by road to plants located close to mines.

- Fluxes figure of 12.7mt is as in the IR Year Book 2006-07.

Table 2: Commoditywise Rail Movement

2006-07

Commodity	Total (mt)	Rail (mt)	Rail Share (%)
Finished Steel	52.5	27.0	29.8
Pig Iron	5.0		
Crude Steel	33.1		
Sponge Iron	18.3	Negligible	Negligible
Raw Material			
Iron Ore	111.9	77.5	69.3
Coal	61.9	50.9	82.2
Fluxes	22.9	12.7	55.7
Total (Raw Material)	196.7	141.1	71.8
Total	**305.6**	**168.1**	**55.0**

[Source: IR MoR, 2008a; MoR, 2008b]

The above stated rail shares for 2006-07 seem to be in line with the estimates made in the NSP for 2004-05 where the rail share stated for raw material was 70% and for finished steel was 29%.

IMPORTANCE OF STEEL SECTOR FOR RAILWAYS

Table 3 gives the overall profile of commoditywise loading, net ton kilometers (NTKM), and earnings that the IR had in 2006-07.

IR earned Rs 82,427 m from the steel industry, which was 20% of IR's total freight earnings. The maximum revenue earning was from iron ore (Rs 28,813 m) followed by pig iron & finished steel (Rs 26,007 m) and coal (Rs 20,396 m).

In terms of yield per mt, pig iron & finished steel was the highest at Rs 963 m and iron ore was the lowest at Rs 372 m, primarily reflecting the average lead of these commodities. In terms of yield per m NTKM, the highest was iron ore at Rs 1.16 m and the lowest was coal at

Rs 0.86 m. This was a consequence of both the classification (for rates) and the lead (due to the telescopic structure).

Table 3: Profile of Steel Sector Commoditywise Rail Movement

2006-07

Commodity	Loading		NTKM	Lead	Earnings		Yield Per mt	Yield per m NTKM	Class
	mt	%	m	km	Rs m	%	Rs m	Rs m	
Finished Steel Pig Iron Crude Steel	27.0	3.7	26,635	986	26,007	6.2	963	0.98	180
Iron Ore	77.5	10.6	24,950	322	28,813	6.9	372	1.16	160
Coal*	50.9	7.0	23,782	467	20,396	4.9	401	0.86	140
Fluxes	12.7	1.7	6,983	550	7,211	1.7	568	1.03	160
Total (Steel Industry)	**168.1**	**23.1**	**82,350**	**490**	**82,427**	**19.8**	**409**	**1.00**	
Total Freight	**727.7**	100.0	**4,80,993**	**661**	**417,175**	100.0	573	0.87	

[Source: MoR, 2008a]

*To calculate NTKM and earnings, 25.3 mt coal moving to 'main' and 'major' producers is prorated on the 'coal to steel plants' figure , and the remaining 25.6mt is prorated on the total coal figure as per the Data Book.

CURRENT ISSUES IN RAIL TRANSPORT

Depending on the rail share and size of the steel plant (Exhibit 2), there may be anywhere from four (for a 0.5mtpa crude steel producer) to nearly 40 rake movements per day (for a 5mtpa integrated steel producer) in and out of the plant. Similar assessments can be made for downstream producers, iron ore mines, coal mines, limestone and dolomite mines, and ports.

Given the significance of rail movement, we examine the issues related to rail transport in terms of infrastructure, technology and systems. These are based on discussions with functionaries in the industry and railways, questionnaire inputs from SAIL corporate office, and four steel plants (RINL, TATA, SAIL, Salem, SAIL, Rourkela), a study visit to JSW Steel, Mormugao port and steel unloading points, and the authors' own perspectives based on prior visits to steel plants, iron ore mines, coal mines and ports.

Infrastructure

Streamlined Movement

- Bypasses and Flyovers: There are many junctions at which reversals take place in absence of a bypass, causing delays to the rake movement and congestion, and consequent asset utilization inefficiency. The same would be true with respect to flyovers in terms of cross movements. For example, in the case of JSW Steel, many rakes undergo reversals, either at Toranagallu, Bellary or Madgaon stations, causing additional delays to rakes of one to four hours.

- Multiple Access: Given the level of traffic at many steel plants, lack of multiple access in and out of steel plants leads to operational complexity, cross movements and consequent congestion.

Connectivity

- Connectivity to Mines: Due to lack of connectivity to mines, short haul movements are performed by road, resulting in IR's decreased market share in the high rated bulk commodity movement of iron ore.

Capacity

- While throughput has been increased by increasing the axle loading from 20.3 to 22.9 tons per axle and even up to 25 tons per axle in certain select routes, line capacity is a bottleneck in many sections. An example is the Hospet - Mormugao port single line section, which services coal imports for JSW Steel. Doubling of this section, and short of that, smaller debottlenecking works are underway. However, project execution is not synchronized with the needs of the steel plant.

Terminals

- Infrastructure at terminals, especially at unloading centres (goods sheds) is quite poor [Raghuram and Bastian, 2008]. Apart from inadequate facilities and equipment, location of such goods sheds based on the 'station based goods shed' concept leads to congestion in the shed and evacuation problems.

Technology

Wagon Loadability

- There are certain commodities eg coking coal, pipes etc that cannot be loaded upto the carrying capacity (CC) of a wagon. In case of coking coal, the actual loadabilility is 58-60t (depending upon the type of coal) while the CC of BOXN wagon is 65t. As a result, the commodities, which cannot be loaded upto chargeable weight, are charged for their fixed chargeable weight based on the type of wagons resulting in idle freight.

Information System

- Though IR has information system called FOIS (Freight Operations Information System) which provides the location of rake en-route. FOIS is sometimes unable to provide the exact location of the rake and expected departure time in case the rake is stranded en-route. Also, free access of FOIS for relevant data is not available as required.

- Steel plants do not get a committed forecast of empty wagons to be supplied within the next 24 hours.

Special Purpose Wagons/Wagon Design

- Wagons are not designed for size or handling of some special types of steel (tinplates, CRNO steel and pipes). BFNS wagons, which transport high quality value added steel like coils, are not designed for protection from atmospheric influences. Customized wagons for specific finished steel products are not available.

- Availability of BFNS wagons is an issue. BRN wagons, which do not have saddles, are used as a substitute. As a result, steel producers need to take extra measures (and invest additional money) to ensure safe delivery of these products.

- BOXN wagons are not properly maintained. They often have problems in loadability of coal and iron ore fines, resulting in loss of material in transit due to spillage, leakage, flying off pilferage etc.

Loading/Unloading Equipments

- Appropriate loading/unloading equipments are not always available at goods sheds. There are problems at loading/unloading points when IR is not able to supply the types of wagons suitable for a particular commodity. In case of loading of CR/HR coils (ideal for loading in BFNS wagons) in BOXN wagons, special equipments (eg crane attachments) are required to load/unload these coils in the desired position.

Systems

Unfit Wagons/Oversize Wagons

- There are frequent incidences of unfit wagons in rakes supplied by IR for loading. For example, for each unfit wagon (at times, upto six unfit wagons in a rake), the complete wagon loader system at Mormugao port has to be stopped to skip the unfit wagon and restarted again. This results in increased cost of loading and time taken for rake loading. Apart from this, these unfit empty wagons cannot move up the ghat section (route that goes through hilly areas with significant grades) as part of the loaded rake, due to which the wagons have to be removed at the foot of the ghat, at high operational costs.

- There are incidences of oversize wagons (BOXNHA) coming with BOXN rakes. These wagons cannot enter into the tipplers as the tipplers were designed to handle a maximum height of BOXN wagon. Such oversized wagons have to be isolated from the parent rake and unloaded manually. This increases detention to the rake and accrual of demurrage.

- Sometimes, wagons supplied by IR for loading come with left over material inside the wagon. This needs clearing up, causing operational complexity and delay for the customer.

Free Time/Demurrage/Idle Freight

- IR's demurrage and free time policy is not consistent towards newer and older steel plants. Newer plants are provided less time for demurrage (Exhibit 3).

  Similarly, IR charges penal demurrage differently from zone to zone.

- While handing over the loaded rakes, steel plants inform railways to take over the rakes in the exchange yard and plant loco takes the rake upto the exchange yard. However, in case there is a problem on railways part to take over the rake, the rake is detained inside the plant for which no extra free time is given. Only on physical arrival of rake at exchange yard, the take over time is recorded by railways.

  Conversely, for empty rakes for steel loading, the demurrage clock starts from the moment the rake arrives at the exchange yard of steel plants, despite the demand time (which could be latter) indicated to railways.

- Due to material like coking coal and iron ore fines becoming sticky during the monsoon months, the unloading time of rakes increases. Earlier, railways used to provide monsoon allowances, which has been withdrawn.

  Loading of long rails (130/260meter from Bhilai) to railway consignee requires more time, but no extra free time is given by railways.

- Steel plants place the indent for supply of empty rakes for dispatch of finished products and specify the type of wagons, type of rake and the demand time. However, there is a mismatch in the actual supply by railways. For example, due to shortage of BOST and BRN wagons, BOXN wagons may be supplied. Since the loadability (the chargeable weight) in the three types of wagons differ, the loading pattern and even the consignee may have to be changed. Apart from operational complexity, there could be demurrage and idle freight charges.

- Bunched arrival of rakes is a major reason for the detention of rakes in the plant. Though bunching allowance is provided by railways, at yards which do not have 24 hour working, the benefit ceases at midnight. This leads to operational complexity without due credit, especially if rakes are placed just before midnight.

Tariff Structure

- As part of its pricing for freight transport, the IR has a concept of categorizing various commodities that it carries into different ‘classes.’ Each class has a price structure which specifies the rupees per ton for different distance slabs. The classification number represents an approximate linear ‘inflation’ over a base price. Over the past few years, IR has increased freight tariff significantly, especially in the case of iron ore, by reclassification (Table 4).

Table 4: Reclassification of Freight Tariff

Year	Iron Ore for Steel Plants	Coal	Limestone & Dolomite	Steel
2004-05	120 130 (29/10-26/10) 140 (27/11-31-03)	140	140	180
2005-06	160 (15/05-31/03)	140	160	180
2006-07	160 (01/04-30/06) 170 (01/07-31/03)	140	160 (01/04-30/06) 170 (01/07-31/03)	180
2007-08	160 (01/04-06/01) 170 (07/01-31/03)	140	160	180
2008-09	180 (01/04-30.04) 170 (01/05-12/10) 180 (13/10-	140 (01/04-07/12) 150 (08/12-	160	180

[Source: MoR, Rates Circulars]

- IR has also increased the tariff through imposition of various surcharges on base freight like (i) busy season surcharge for nine months of the year, (ii) development surcharge, (iii) charges for using railway goodshed/siding, and (iv) multipoint booking surcharge.

- IR has also brought various incentives and discount schemes to customers. However, incentives schemes have many other conditions that some of the customers are not able to take any advantage. Further, there is delay in passing the benefits to customers.

- The number of freight rate circulars have been on the rise from 35 and 55 during 2003 and 2004 respectively to a range of 76 to 114 during the period 2005-2008. This makes it difficult for the customers and even for the railway officials to function, since before the absorption of the implication of one, another gets issued.

- The tariff structure has changed over the years, resulting in ores being charged at the same rate as steel. While this may not appear logical, especially as a proportion of the value of the product, it reflects a competitive perspective that IR has brought in into its tariff policy.

Weighing System

- There are occasions when weighbridge readings of railways are questionable, especially when it reflects a figure that would have been impossible to load. Punitive charges are also levied as per rules on these questionable weighments and refunds are then considered in a slow bureaucratic manner. IR does not accept the weighing records given by the raw material suppliers or the steel industry.

Rake Availability

- Preference in rake allotment is given to iron ore for exports rather than for steel plants. This becomes a risk for steel plants, who need to buffer with inventories. [Dave, Pandey and Sahni, 2008]

Multimodal Issues

- Due to lack of end to end solutions by IR, even in sections where it has competitive advantage over other modes eg mines to ports, commodities are handled by more than one mode. As an example, iron ore movement from mines in Hospet-Bellary region to Panaji/Mormugao port is executed by as many as four modes for a distance of less than 600 kms (Exhibit 4).

- Presently, dispatch of pipes is mainly by road transport as requirement of pipes are mostly at various project sites and away from major railway sidings. Railways do not provide a method to transport such pipes by bridging through road transport from the nearest railway station to the project site.

Claims/Refunds

- Customers find claim settlement mechanisms of IR very protracted. There are complaints of delays in refunding excess payments. This happens even in e-payment processes. The Railway Rates Tribunal could be more effective.

Logistics Issues

- Rail provides only transportation while road transport carriers take various responsibilities including packing, securing and protection, and coverage of losses.

- Railways are gradually reducing the number of 2-point rakes for steel dispatches, although it provides a lot of flexibility to the steel plants and the customers. Railways have indicated that in future, the facility of 2-point rakes for steel despatches is likely to be withdrawn.

- Despatch of finished goods to minor destinations is a problem since rake load build up takes a while.

CONCLUSIONS

Based on the estimated transport requirements (Table 1) for the steel sector in 2011-12 and 2019-20, we project the rail transport requirements by using the existing rail share (Table 2) and desirable rail shares of 50% for crude and finished steel, and 100% for raw materials. These projections are provided in Table 5.

The originating tonnage could go up from 168mt in 2006-07 to between 330-480mt in 2011-12 and 660-965mt in 2019-20. While steel transport requirements are expected to quadruple from 305mt in 2006-07 to 1200mt in 2019-20, the rail tonnage has the potential of going up six fold to nearly 1000mt, if appropriate steps in infrastructure, technology and systems are taken.

Table 5: Rail Transport Projections, 2011-12 and 2019-20

2011-12

Commodity	Total (mt)	Rail Share (%)		Rail Movement (mt)	
		Existing	Desirable	At Existing Share	At Desirable Share
Finished Steel	100	29.8	50.0	49.2	82.5
Pig Iron	8				
Crude Steel	57				
Sponge Iron	35	Negligible		Negligible	
Raw Material					
Iron Ore	225	69.3	100.0	155.9	225.0
Coal	130	82.2	100.0	106.9	130.0
Fluxes	45	55.7	100.0	25.1	45.0
Total (Raw Material)	400	71.8	100.0	287.2	400.0
Total	600	55.0	80.4	330.0	482.5

[Source: Authors' Analysis]

2019-20

Commodity	Total (mt)	Rail Share (%)		Rail Movement (mt)	
		Existing	Desirable	At Existing Share	At Desirable Share
Finished Steel	200	29.8	50.0	98.4	165.0
Pig Iron	16				
Crude Steel	114				
Sponge Iron	70	Negligible		Negligible	
Raw Material					
Iron Ore	450	69.3	100.0	311.8	450.0
Coal	260	82.2	100.0	213.8	260.0
Fluxes	90	55.7	100.0	50.2	90.0
Total (Raw Material)	800	71.8	100.0	574.4	800.0
Total	1200	55.0	80.4	660.0	965.0

[Source: Authors' Analysis]

Infrastructure

- The origin-destination (OD) flows at a disaggregate level would give a better assessment for validating the rail share and infrastructure requirements. Key parameters to be conscious of would be the market spread, expected parcel sizes, OD lead, nature of source (mine, port, or plant), nature of destination (plant, stockyard, or port). The authors have developed a model for such an assessment for the IR freight as shown in Exhibit 5. In this model, which is at an aggregate level for the entire IR traffic, the authors have categorized origins and destinations on attributes that have implications for providing services including door to door delivery, 24 hours loading/unloading, automation of loading/unloading, and development and ownership of siding etc. These origins and destinations are industry/collection centre, mine and port for originating traffic, and industry, port and distribution centre for terminating traffic. The traffic is assigned to each OD segment in a matrix using a two-way classification.

IR should assess the OD flows of finished and crude steel, pig iron and sponge iron, and raw materials for steel making and plan the infrastructure in terms of route capacity, terminals and rake requirements.

- Port connectivity requirements can be assessed based on Table 1. For plant to port flows, in terms of finished steel, 25% is expected to be exported, of which 50% would move by rail. Similarly, for port to plant flows, in terms of raw materials, 100% of coking coal/coke, 50% of thermal coal, and 20% of fluxes are expected to be imported, of which 100% would move by rail. For 2019-20, these would translate to 25mt of finished steel, 200mt of coking coal/coke, 30mt of thermal coal, and 20mt of fluxes. Hence, steel plant port connectivity infrastructure should be developed, recognizing this level of movement.

- Rail based unloading stockyards for finished steel would need to be developed for handling upto 75mt in 2019-20. Of this, the demand would be concentrated in areas near metros. It would be fair to expect that 50mtpa would be unloaded in the top 10 metro areas with a throughput of 5mtpa each. For these metros, captive unloading stockyards (steel logistics parks with warehousing infrastructure) with sophisticated infrastructure and evacuation options should be developed under a public private partnership model.

Technology

- IR should continue the thrust towards increased axle loading, special purpose wagon design, and ensuring loadability to minimize idle freight. The standards for the dedicated freight corridor should recognize these.

- Containerized movement of finished steel has begun. This has significant potential and should be facilitated, both due to its multi modal possibilities and the scope of leveraging the private container operators.

- For raw material handing at tipplers, rotary couplers should be incorporated in the wagon design for quicker unloading.

- There should be focus on special purpose wagon design to facilitate commodity specific handling and logistics requirements. For example, being able to load coils in 'eye horizontal' position would reduce losses and make it easier for handling.

- While special purpose wagon design has its advantages, a perspective on using the same wagon for inward and outward could reduce transportation costs significantly.

Plants and ports have substantial inward and outward movement. The maximum scope for this concept is 165mt at plants, implying 330 rake movements per day and 25mt at ports, implying 50 rake movements per day.

- Continuous improvement in wagon design is a must. To ensure this, the IR policy of allowing any entity including wagon manufacturers to come up with wagon designs should be sustained. The RDSO should be the body to accept the wagon design, after due simulations and trials.

- There should be complete visibility on wagon and rake movements. Technologies such as GPS and RFID should be used for this. Information systems such as FOIS should be made more integrated, robust, and user friendly.

Systems

- Supply chain coordination with customers and suppliers should be of a significantly higher order. Using FOIS, trains movements in and out of mines, ports, plants and unloading centres should be regulated to ensure streamlined logistics.

- While 3000 tons plus parcel sized rakes are in general okay, there could be OD segments for which customers may not be able to bear the inventory related costs. Depending on the opportunity cost of capacity on such segments, smaller, but modular rake sizes should be considered.

  In the same context, multi-point rakes, especially for smaller stockyards, should be leveraged.

- There is significant strategic opportunity in leveraging the empty spaces in steel carrying wagons. Steel is a high density cargo, in the range of 7500-8000kg/m^3. A typical steel loading wagon has a volume of about 70m^3. When steel coils of 65-67 tons are loaded in a wagon, it occupies only about 12% of the wagon's volume (Exhibit 6a). If steel is loaded together with a compatible low density cargo (for example, packaged bulk agricultural products), there can be significant revenue additionality for IR (Exhibit 6b). As one example, there is a significant movement of agricultural products from Jharkhand state to the National Capital Region (NCR). Jharkhand has significant steel production and dispatches finished steel to the NCR. A possibility can be explored to combine the transportation of steel coils with the agricultural products. IR can go a step further and leverage such opportunities, if required by influencing the development of industries with compatible cargo.

Exhibit 1
Lack of Clarity in IR Freight Data wrt Steel Industry

Publication	Head	Remark
Year Book	Raw materials to steel plants	Which raw materials are included? Which steel plants are included?
Year Book	Limestone & dolomite	Split for steel plants?
Year Book	Pig iron and finished steel from steel plants	Which steel plants are included? Clarity on how are these two figures different?
Year Book	Iron & steel	
Data Book	Coal for steel plants	Is thermal coal to power plants captive to steel plants included? Which steel plants are included?
Data Book	Coal to thermal power houses	Is thermal coal to power plants captive to steel plants included?
Data Book	Iron ore for steel plants	Which steel plants are included?
Data Book	Iron ore for other users	Who are these other users?
Data Book	Pig iron and finished steel from other points	Which are these other points?

[Source: MoR, 2008a; MoR, 2008b; Authors' Analysis]

Exhibit 2
Steel Plants (Above 0.5mtpa Capacity)

2006-07

	Plant	Location	Capacity (mtpa)	Crude Steel Production (mtpa)
1.	Tata Steel, Jamshedpur	Jharkhand	5.00	5.17
2.	SAIL, Bhilai	Chattisgarh	3.92	4.80
3.	SAIL, Bokaro	Jharkhand	4.36	4.07
4.	Rashtriya Ispat Nigam Ltd, Vishakhapatnam	Andhra Pradesh	2.91	3.50
5.	Ispat Industries Ltd, Raigarh	Maharashtra	3.00	2.76
6.	JSW Steel, Vijayanagar	Karnataka	3.80	2.64
7.	Essar, Hazira	Gujarat	4.60	2.40
8.	SAIL, Rourkela	Orissa	1.90	1.99
9.	SAIL, Durgapur	West Bengal	1.80	1.87
10.	Jindal Steel & Power Ltd, Raigarh	Maharashtra	1.37	0.80
11.	Jindal Stainless Ltd, Hisar	Haryana	0.60	0.59
12.	Lloyds Steel Ltd, Wardha	Maharashtra		0.54
13.	SAIL, IISCO	West Bengal	0.50	0.47
	Total of Above			***31.60***
	Others			19.22
	Total			**50.82**

[Source: MoS, 2008]

Exhibit 3
Free Time and Demurrage

Free Time: It's the time from Rake arrival at site until the rake is handed over back to the Railways after completion of loading/ unloading activities.

Free time for loading/unloading of wagons and allowances applicable in the case of seven old steel plants

Seven old steel plants namely Bhilai Steel Plant, Bokaro Steel Plant, Durgapur Steel Plant, Indian Iron & Steel Co., Rourkela Steel Plant, Tata Iron & Steel Co. and Visakhapatnam Steel Plant will be permitted free time as prescribed below:

Type of Wagon	Name of the Steel Plant	Number of Wagons	Permissible free time (in Hours)	
			Loading	Unloading
Open Wagons	Visakhapatanam Steel Plant	Upto 35	16	8
		36 & above	18	10
	Indian Iron and Steel Co	Upto 35	24	16
		36 & above	26	18
	All Others	Upto 35	22	12
		36 & above	24	14
Flat Wagons	All	Upto 35	24	12
		36 & above	26	14
Hopper Wagons	All	Upto 45	N.A	8
		46 & above	N.A	10
Covered Wagons	All	Irrespective of the number	24	24
Tank Wagons	All	Irrespective of the number	24	24

Free time for loading/unloading of wagons and allowances applicable in case of all other steel plants

Permissible free time for loading/unloading of wagons and allowances applicable in the case of steel plants other than the above mentioned seven old steel plants will be as under:

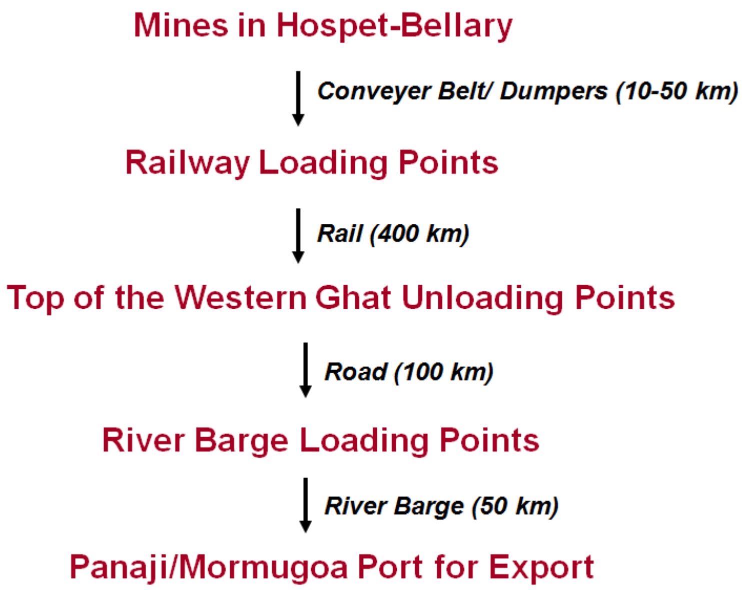
Type of Wagon	Number of Wagons	Permissible free time (in hours)	
		Loading	Unloading
Open Wagons	Irrespective of number of Wagons	12	8
Flat Wagons		12	8
Hopper Wagons		N.A	4
Covered Wagons		10	10
Tank Wagons		9	9

Demurrage: Demurrage is the charge levied for the detention of any rolling stock after the expiry of free time, if any, allowed for such detention.

Rates of demurrage Charge
In case of steel plants, demurrage charge @Rs.50/- per 8-wheeled wagon per hour, or part of an hour, for detention of wagon in excess of the permissible free time for loading or unloading, shall be levied.

[Source: MoR, Rates Circular No 74 of 2005]

Exhibit 4
Multimodal Movement of Iron Ore



[Source: Authors' Analysis]

Exhibit 5
Origin Destination Flow for IR (2006-07)

Total Traffic: 727.8mt

Origin \ Destination	Industry (411.3)	Ports (78.3)	Distribution Centres (238.2)
Industry/ Collection Centres (224.5)		Containers (16.4) POL (5.6) Total (22.0)	Cement (73.1) Foodgrains (39.0) Fertilisers (27.2) Iron and steel (25.5) POL (17.2) Other commodities (12.2) Salt (4.6) Sugar (3.7) Total (202.5)
Mines (424.1)	Coal (261.5) Iron ore/other ores (80.3) Limestone/dolomite (12.7) Stones, excl marble (10.0) Gypsum (3.2) Total (367.8)	Iron ore/other ores (40.9) Coal (15.4) Total (56.3)	
Ports (79.1)	Coal (36.4) Other commodities (6.6) Iron ore/other ores (05) Total (43.5)		Containers (15.3) POL (8.9) Fertilisers (7.1) Foodgrains (2.8) Iron and steel (1.6) Total (35.7)

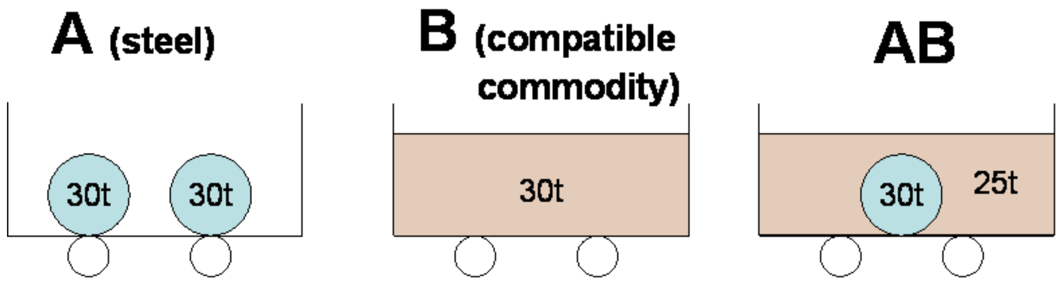
[Source: Raghuram and Gangwar, 2008]

Exhibit 6a
Weight Volume Mix

	BFNS Wagon	BOXN Wagon
Wagon dimensions (mm) Length Height (loadable) Width	 13716 1650 3045	 9784 2233 3200
Wagon volume (m3)	69	70
Steel density (kg/m3)	7861	
Steel volume at 65 tons (m3)	8.3	
Steel volume at 67 tons (m3)	8.5	
Wagon utilization (%)	12.0	12.1

[Source: Authors' Analysis]

Exhibit 6b
Weight Volume Mix



A: We consider nine wagons, each carrying 60 tons of steel, limited by weight. (A total of 540 tons)

B: We consider 15 wagons, each carrying 30 tons of a compatible cargo (CC), limited by volume. (A total of 450 tons)

AB: Instead of the 24 wagons, the 540 tons of steel and 450 tons of CC can be carried in 18 wagons, each carrying 30 tons of steel and 25 tons of CC.

The AB type of loading provides a saving of 25% on total wagon requirements.

About 27mt of steel were loaded in 2006-07. At a 60 ton per wagon loading, this amounted to 450,000 wagons of steel loading. We assume the availability of 750,000 wagon equivalent of CC (22.5mt) going in the same OD segments as the steel. Out of the total 1,200,000 wagons, with a total loading requirement of 49.5mt of steel and CC, at a 55 ton per wagon loading, 900,000 wagons would be loaded. A total of 300,000 wagons would be released for alternate use.

This has a potential revenue additionality of Rs 1500 crores, assuming a release of 300,000 wagons for a lead of 1000 kms (approximate lead for steel), with a loading of 50 tons, and earning of Rs 1 per ton km.

[Source: Authors' Analysis]

GLOSSARY

BFNS	Flat wagons for loading coils
BOST	Open top wagon (with carrying capacity of approximately 55 tons)
BOXN	Open top wagon (with carrying capacity of approximately 58 tons)
BOXNHA	Open top BOXN wagon with higher axle loading
BRN	Air-braked wagon with CASNUB bogies
CAGR	Compounded Average Annual Growth Rate
CC	Carrying Capacity
CR	Cold Rolled
FOIS	Freight Operations Information System
GPS	Global Positioning System
HR	Hot Rolled
IR	Indian Railways
MOR	Ministry of Railways
MoU	Memorandum of Understanding
NSP	National Steel Policy 2005
NTKM	Net Ton Km
OD	Origin-destination
RDSO	Research Design and Standards Organization
RFID	Radio Frequency Identification

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