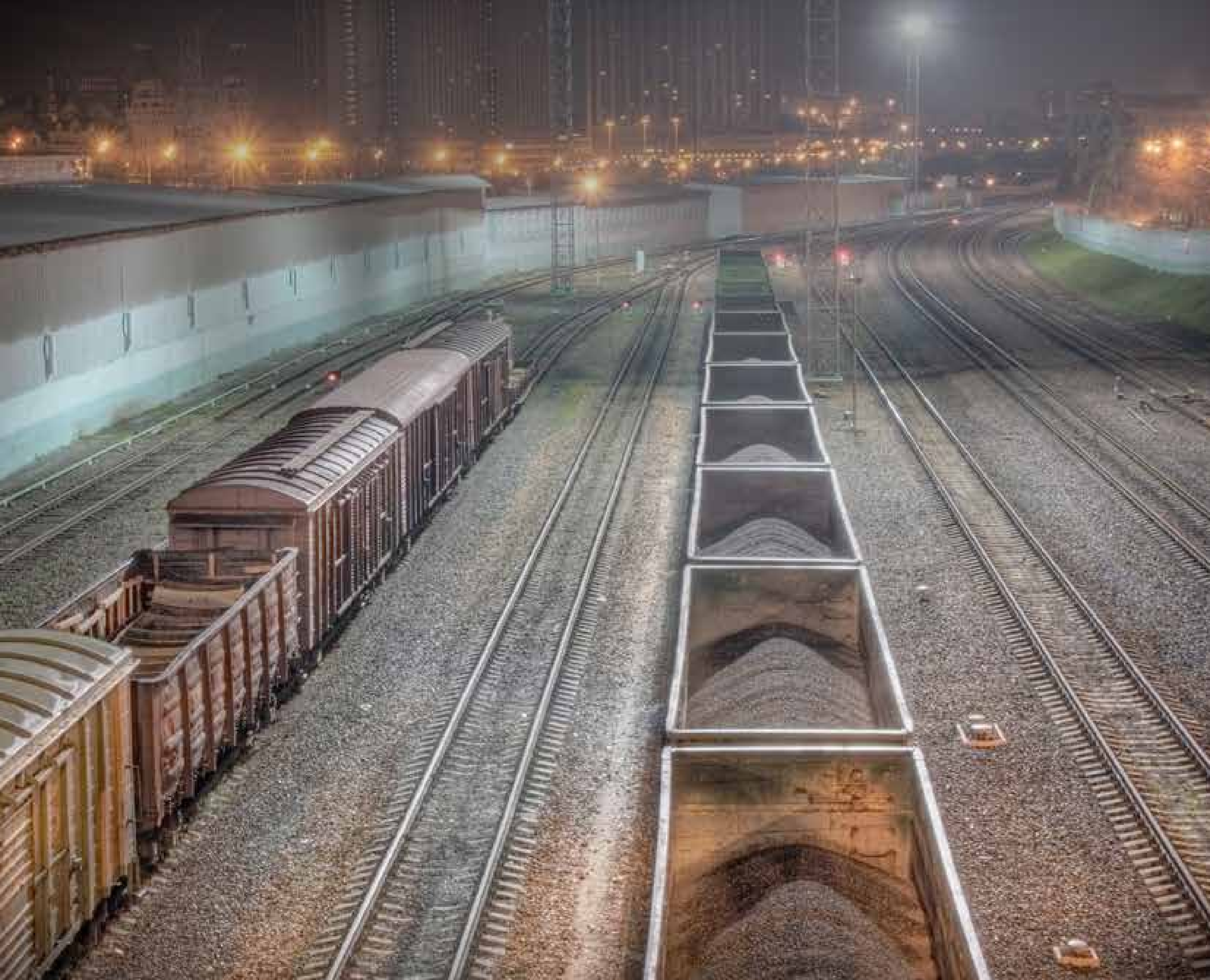
INDIAN RAILWAYS AND COAL

AN UNSUSTAINABLE INTERDEPENDENCY



PUNEET KAMBOJ
RAHUL TONGIA

BROOKINGS INDIA

BROOKINGS INDIA

No. 6, Second Floor, Dr. Jose P Rizal Marg
Chanakyapuri, New Delhi - 110021
www.brookings.in

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Vivek Sahai is a Distinguished Fellow with the Observer Research Foundation in Mumbai with operations expertise in traffic, transportation, and logistics. He has formerly served as Chairman of the Railway Board and has been involved in planning a number of transportation projects including the Chhatrapati Shivaji Terminus in Mumbai and has assisted the National Transport Development Policy Committee of the Planning Commission.

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About the authors

Puneet Kamboj

Research Assistant, Energy & Sustainability, Brookings India

Kamboj specialises in techno-economic and policy analysis in power, renewable energy and transportation. He has previously authored a study on the estimation of rooftop solar potential for the Varanasi city, and spent six months at KAPSARC, Riyadh, where he studied and standardised Indian road and railway freight transport as per the World Input Output Database (WIOD) to enable international comparisons and benchmarking. Prior to this, he also had two years of lecturing experience on thermodynamics and heat transfer at the mechanical engineering department at LPU, Jalandhar.

Kamboj has a B. Tech in Mechanical Engineering from MDU, Rohtak and a M. Tech in Renewable Energy Engineering and Management (REEM) from TERI University, New Delhi.

Rahul Tongia

Fellow, Energy and Sustainability, Brookings India

An expert in technology, policy and design of infrastructure, Tongia's research covers energy, electricity and sustainable development, with additional expertise in information technology and telecommunications. Much of his work focuses on sustainable energy, including smart grids, which use innovative information and communications technology to improve management of the electricity grid; renewables and renewable integration; shortfalls of electricity and mitigation measures; and electricity pricing. He is also Adjunct Professor at Carnegie Mellon University, and was the founding technical advisor for the Government of India's Smart Grid Task Force and the India Smart Grid Forum.

Tongia has a Bachelor's degree in Electrical Engineering from Brown University and a Ph.D. in Engineering and Public Policy from Carnegie Mellon University, Pittsburgh.

Abbreviations and Acronyms

BU	Billion Units (kWh)
CIL	Coal India Ltd.
DFC	Dedicated Freight Corridor
DisCom	Distribution Company (electricity)
HVDC	High Voltage DC (electricity transmission)
IR	Indian Railways
kWh	Kilowatt-hour (electricity)
MT	Million Tonnes
PKm	Passenger Kilometre
PLF	Plant Load Factor
RE	Renewable Energy
TKm	Tonne Kilometre (Net basis)
TPP	Thermal Power Plant

Definitions

Average lead of traffic: Represents the average distance each passenger or tonne of freight is transported. Calculated as the ratio of passenger kilometre to passenger carried for passenger traffic and tonne kilometre to tonnes carried for freight traffic.

Class: Categorisation of rate for freight by category compared to a class 100 being a basis. Class 145 for coal means being charged per tonne kilometre (TKm) 1.45 times that charged for a class 100 good.

Coal linkage rationalisation: The process of reallocating coal linkages from relatively distant coal mine to a similar quality coal mine nearer to the power plant, to cut down transportation costs.

Fare-to-freight ratio: Ratio of passenger revenue per passenger kilometre to freight revenue per tonne kilometre.

Freight rate: Money realised by railways for transportation of goods; includes not just the rates as notified but also surcharges, loading/unloading fees, etc.

Net tonne kilometre: Unit of measure of freight traffic corresponding to movement of one tonne of freight (including the weight of any packing, but excluding the weight of the wagon used for transport) over a distance of one kilometre. If the wagon weight is included it is the gross TKm.

Operating ratio: The ratio of working expenses (excluding suspense but including Appropriation to Depreciation Reserve Fund and Pension Fund) to gross earnings.

Passengers carried: This represents the number of passengers originating on each railway as well as the number of passengers received from other railways and also those crossing the railways.

Passenger fare: Money realised by railways from transportation of persons; average is calculated across all passenger segments.

Plant load factor: Measure of the utilisation rate of a power plant; 100 per cent means a 1 kW plant generates power at rated load 24 hours a day, 365 days a year, usually infeasible.

Passenger kilometre: Unit of measure of passenger traffic corresponding to carrying a passenger over a distance of one kilometre.

Revenue earning traffic: Traffic conveyed by rail and for which commercial tariffs are applied i.e. for transportation of which the railway is paid by either the consignor or the consignee

Subvention: An amount of money given as support by a government for a particular purpose i.e. in this case passenger subsidy.

Tonnes carried: This represents the quantum of goods originating on each railway as well as the quantum of goods received from other railways/gauges and also those crossing the railways.

Contents

Key Points

1. Coal and railways in India are heavily interdependent.
    a) In the Financial Year (FY) 2017, out of 574 MT of coal (inclusive of imports) consumed for grid electricity generation (Central Electricity Authority, 2017), 341 MT, or 60 per cent, was transported through railways (Railway Board, March 2017). On average railways accounts for over 85 per cent of costs for transporting coal to thermal power plants, as a number of power plants are pithead/near coal mines and do not use this mode for transportation.

    b) Coal is 44 per cent of IR's freight revenues and has an even higher share in its profits. **Indian Railway's (IR) business model is based on passengers underpaying and freight overpaying.**

2. Revenues from freight carried comprise a combination of the following three components: tonnes carried, distance carried (whose product becomes tonne-kilometres or TKm), and price charged (Rupees/TKm). **IR's average distance of coal transported (called "lead") to thermal power plants (TPPs) has fallen 30 per cent in the past five years which impacts revenues.** This has happened mainly due to a one-time effort towards coal linkage rationalisation and also due to falling power plant load factors (PLFs). **On the contrary, to maintain total revenue, IR coal freight charges have grown more than four times the wholesale inflation rate during FY 2012 to FY 2017.**

3. **Despite higher passenger volumes on a shared network, India has the lowest fare-to-freight ratio**—the ratio of passenger fares and freight charges—**of 0.24, compared with several other countries including Japan (1.9), Germany (1.5) and China (1.2).** This conscious policy choice to keep passenger fares low results in freight overpaying its share.

4. **Railways today explicitly over-prices coal freight by about 31 per cent to offset its "social obligation" or coaching losses.** In FY 2017, this "overcharge" from coal to TPPs (~Rs. 108 billion or Rs. 10,800 crores) **increases the cost of power, on an average, by about 10 paisa per kWh** on the basis of all electricity generated in India. For coal carried by railways, on average, this number is Rs. 0.21/kWh in FY 2017. For power plants in distant states, which inherently rely on railways for coal, this number can be three times higher.

5. **A Brookings India bottom-up coal demand model[1] for FY 2030 forecasts a slower growth in total coal requirement in the country than the past, driven by a combination of falling electricity growth rates, improved power plant efficiencies**

[1] Brookings India analysis, "Electricity Demand and Supply in India, 2030", by Mohd. Sahil Ali (forthcoming).

(especially the advent of super-critical coal power plants), and the rise of renewable energy (RE). This issue is worsened by the projected slowdown in railway traffic growth for coal. While coal demand continues to grow through FY 2030 in absolute terms, its growth rate declines.

IR may fare worse as what matters more for railways is the location of coal demand. Not only will growing RE displace coal generation but the share of RE will disproportionately grow in states with high solar and wind resources - coincidently those far from coal mines. For distant locations, the rise of high-voltage DC (HVDC) technologies has meant it can be cheaper and more efficient to send power over the wire than transport coal by railways. The economics are further skewed due to coal cross-subsidising passengers.

6. Planned capacity of coal power plants is mostly either pithead/near coal mines or coastal, compared to now when capacity is relatively distributed across the country. Coastal plants are designed for imported coal, which, although expensive per tonne, is still cheaper after adding transportation costs and levies.

   Projections and modelling for the future suggest that **to keep railways solvent based entirely on the cross-subsidy model would result in a freight rise that would make coal (and thus thermal electricity) uncompetitive.**

   If passenger fares increase at a compounded annual growth rate (CAGR) of 4.5 per cent (same as historical FY 2006-17) and railways continues to overcharge freight to recover passenger losses pro rata, in FY 2030 the average "overpayment" per kWh will increase to 18 paisa per kWh in real terms on the basis of all electricity generated, compared to 10 paise per kWh in FY 2017. Naturally, the costs would be far higher in nominal terms, and also higher in distant locations.

[2] In terms of FY 2017 real rupees by deflating FY 2030 nominal rupees, assuming a 3.5 per cent wholesale inflation rate.

1. Introduction: Coal and Railways are deeply intertwined

The majority of India's coal reserves are concentrated in the eastern parts of India, while consumption of coal is scattered all across the country. Because of this uneven geographical distribution in coal supply and demand, transportation of coal plays an important role in the ecosystem. In FY 2017, the total raw coal supplied[3] in India was 842 million tonnes (MT) (Ministry of Coal, 2017), of which 533 MT (Railway Board, 2018) was transported through railways.[4] The volume of coal carried by Indian Railways (IR) was 48 per cent of its total freight in tonnes, and accounted for 45 per cent of its total freight revenue. Coal users and the railways would both collapse without the other.

More than volumes and financials, the relationship between coal and railways runs deep at an institutional level. A senior railways officer is deputed to Coal India Limited (CIL) for coordination, and CIL members work closely with the traffic division of railways. The process is relatively plan-oriented and schedules for traffic are projected a year ahead or even further. There are limited market-oriented mechanisms for allocation of transportation capacity – all end-users can ask for railways haulage as available. Any short-term shock to the system like heavy regional rains, low hydropower output, or diminished RE output during the windy season can cause an imbalance beyond the buffer capacity of the system. More importantly, even buffers, e.g., the minimum stockpiles of coal that all power plants are expected to maintain, are often not enough.

1.1 Historical Trend of IR's traffic

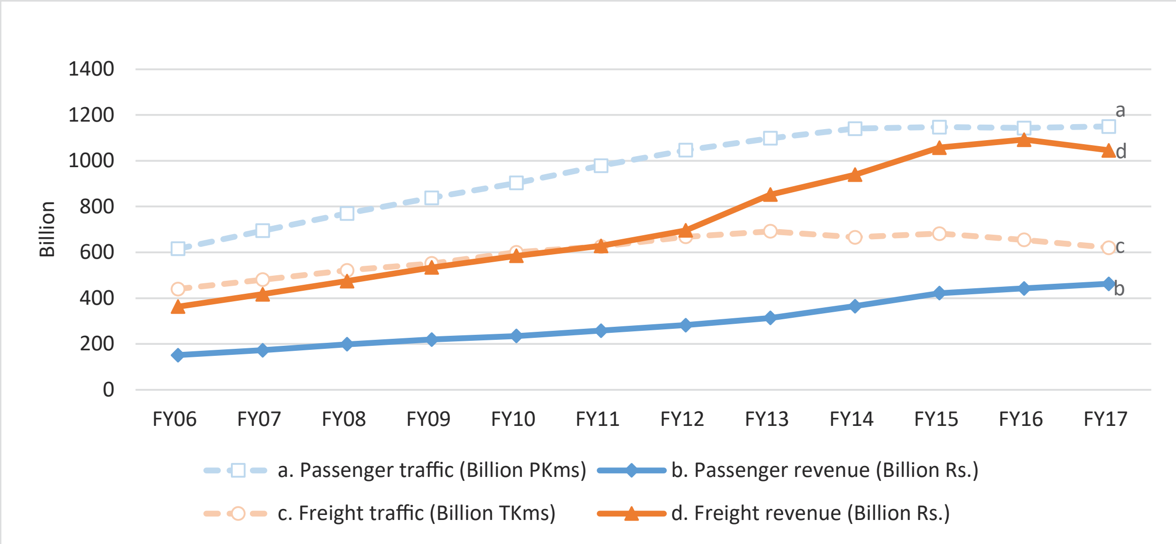
Indian Railways is one of the largest railway systems in the world, both in terms of network length as well as passenger and freight services. Its passenger volume (passenger kilometres, or PKms) is the highest in the world (International Union of Railways, 2015) and it carries more than a billion tonnes of freight every year. Figure 1 shows the trend of PKms, freight tonne-kilometres (TKms) and their respective revenues over the past 11 years.[5]

[3] Coal consumed will be less than the total coal supplied due to stockpiling (which varies over time and in any given year may not average out).

[4] The number includes imported coal. Railways have a higher share on a domestic coal basis.

[5] This paper ends with FY 2017 data as FY 2018 data are preliminary or not available yet with corresponding granularity. While any year-to-year change may appear large, focusing on an 11-year period to define "historical" helps smoothen out such cyclic variations.

Figure 1: Historical trend of PKms & TKms and their respective revenues from FY 2006 to FY 2017



Source: IR Annual Statistical Statements.

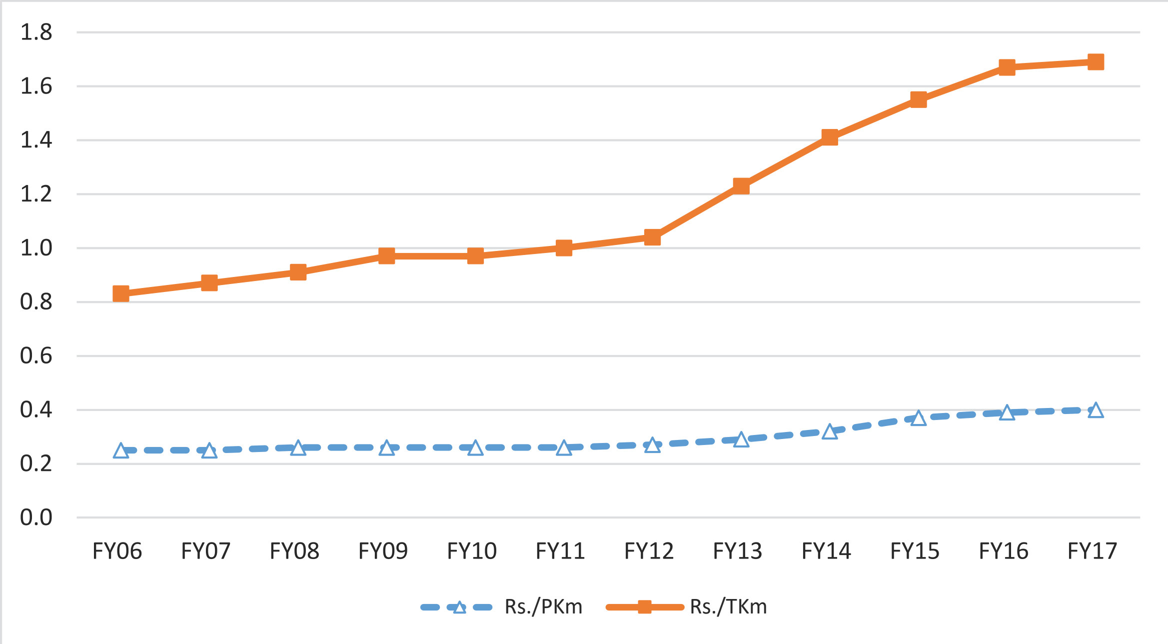
Historically (FY 2006-2017), passenger kilometres have been growing at a faster rate (5.8 per cent CAGR) than freight tonne-kilometres (3.2 per cent CAGR) and the revenue from both has grown roughly at a CAGR of 10 per cent. Since railways' traffic revenue depends on the rate it charges to carry one passenger or one tonne per kilometre, it is better to compare the revenue per passenger kilometre with revenue per tonne kilometre over these years. Figure 2 shows the trend of Rs./PKm and Rs./TKm over these years.

Table 1: Indian railways historical data and CAGR (FY 2006-FY 2017)

IR's Historical CAGR	FY06	FY17	CAGR
Passenger kilometres (Million)	615,614	1,149,835	5.8%
Passenger revenue (Billion Rs.)	151	463	10.7%
Rs./PKm	0.25	0.40	4.6%
Cost of passenger services (Billion Rs.)	217	858	13.3%
Coaching loss (Billion Rs.)	66	396	17.7%
Freight tonne kilometres (Million)	439,596	620,138	3.2%
Freight revenue (Billion Rs.)	36,287	104,563	10.1%
Rs./TKm [all freight]	0.83	1.69	6.7%
Cost of freight services (Billion Rs.)	29,721	64,998	7.4%

Note: Calculated using data from IR Annual Statistical Statements.

Figure 2: Historical trend of Rs./PKm vs Rs./TKm from FY 2006 to FY 2017



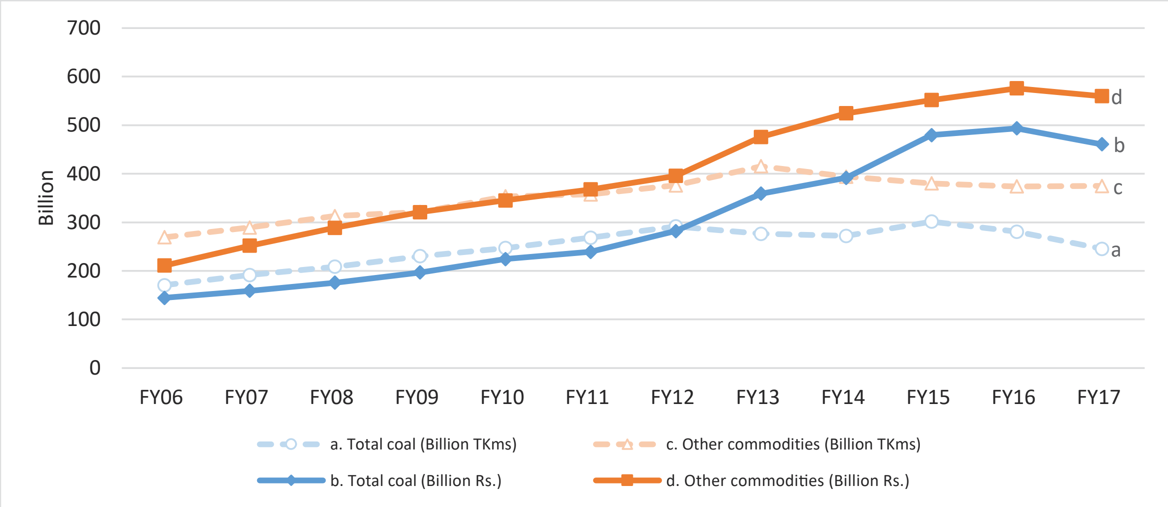
Note: These are nominal rupees.
Source: IR annual statistical statements.

Figure 2 shows that Rs./PKm was relatively flat over the last 11 years whereas Rs./TKm grew at a faster rate overall, especially after FY 2012.

1.1.1 Trend of coal and other freight traffic

Coal is the largest freight commodity transported by IR, both in terms of volume and revenue. In FY 2017, coal contributed to around 40 per cent of the total freight TKms and accounted for 45 per cent of IR's freight revenue (Railway Board, 2018). Figure 3 shows that the revenue from coal has grown at a faster rate than from other commodities, whereas the TKms have grown at relatively similar rates. This is despite coal TKms showing a falling trend over the past few years.

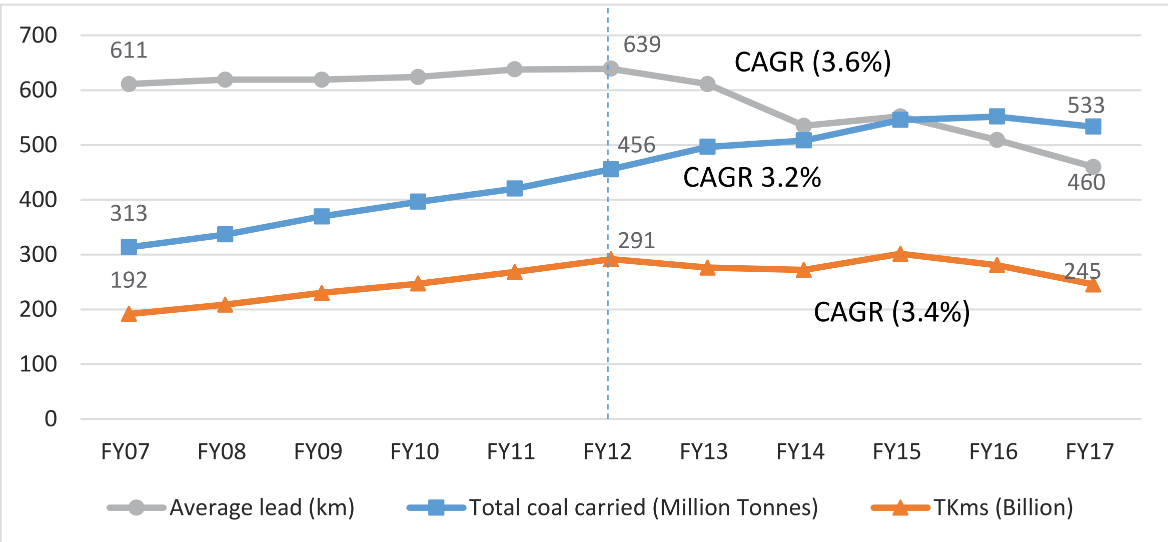
Figure 3: Historical trend of TKms and revenue of coal and other commodities from FY 2006 to FY 2017



Source: IR Annual Statistical Statements.

The main contributing factor of falling TKms is the decline in the average lead of coal despite the increasing volume of tonnes carried. Figure 4 shows that the average lead of coal has fallen from 639 km in FY 2012 to 460 km in FY 2017, while the tonnes carried have increased from 456 MT to 533 MT in the same duration. As a result, the total coal TKms have fallen from 291 billion TKms in FY 2012 to 245 billion TKms in FY 2017 (Railway Board, 2018). Falling average lead can be attributed to the fact that the plant load factor (PLF) of power plants that are distant from coal mines (Arora, 2017) have been falling since after FY 2012 and to the one-time coal linkage rationalisation done by the Ministry of Power.

Figure 4: Historical trend of IR's total coal traffic from FY 2007 to FY 2017

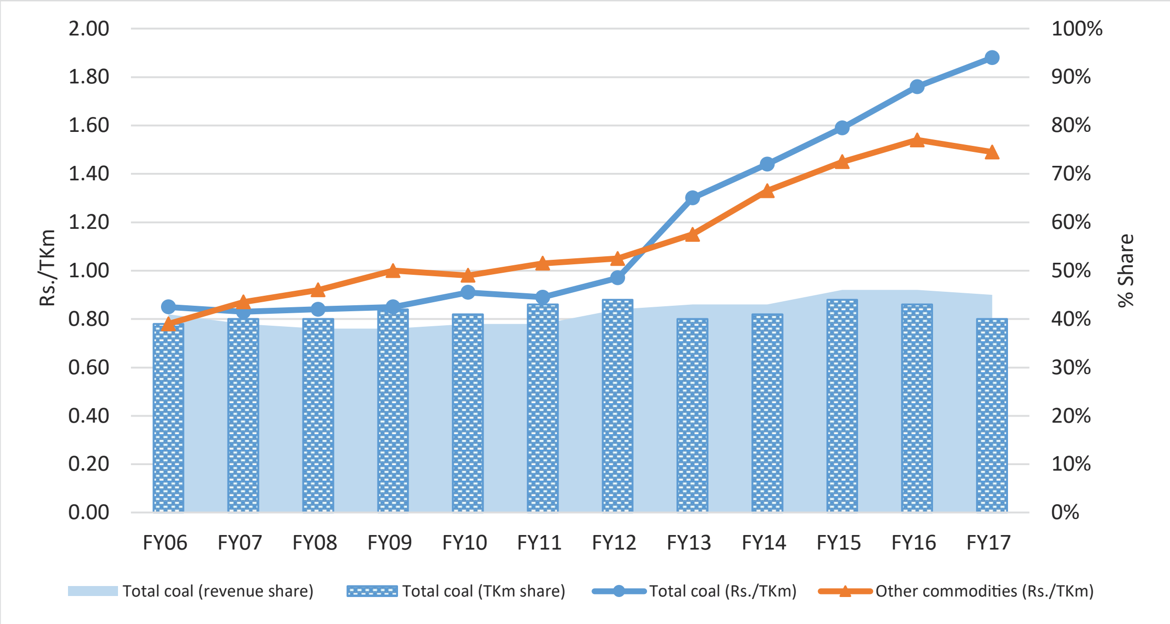


Note: Average lead is calculated by dividing TKms and million tonnes carried. The fall in average lead for coal traffic to TPPs has been steeper than for total coal. TPP coal has fallen from 708 km in FY 2012 to 496 km in FY 2017. The mid-points shown are for FY 2012.

Source: IR annual statistical statements.

IR has responded to falling TKms of coal by raising coal freight rates at a higher rate than other commodities to offset the decline in coal revenues.[6] Figure 5 shows the trend of Rs./TKm for coal versus other commodities and the share of coal traffic in terms of TKms and its revenue from FY 2006 to FY 2017. While this may work for railways in the short run, in the long run, it will risk the end-user, especially thermal power plants (TPPs), who will either find delivered coal prices more expensive than alternatives such as RE or start preferring other modes of transportation, such as trucks. Other areas of competition include coastal regions that import coal, or the rise of long-distance power transmission, especially via high-voltage DC (HVDC).

Figure 5: Trend of Rs./TKm for coal vs other commodities and the share of coal traffic in terms of TKms and revenue



Note: Total coal combines coal transported to power plants and to other users.

Source: IR annual statistical statements.

1.2 IR's financial framework

Indian Railways is an arm of the Government of India (GoI) and a government department. Nonetheless, it is also seen by the government as a commercial entity which paid dividends to the GoI like any other public sector company until FY 2016 when its budget was merged with the general budget. There is a dichotomy in the mandate of Indian Railways: while the Government of India sees it as a social organisation meant for public service, it also sees it as a commercial outfit that must earn profits. To fulfil the government's vision of connecting the country, IR ends up cross-subsidising passengers by overcharging freight. IR is not allocated any budgetary support for passengers, for example in the form of subsidies; any support from government is only to be used for expansion.

[6] Appendix 3 on price revision and frequency has more details.

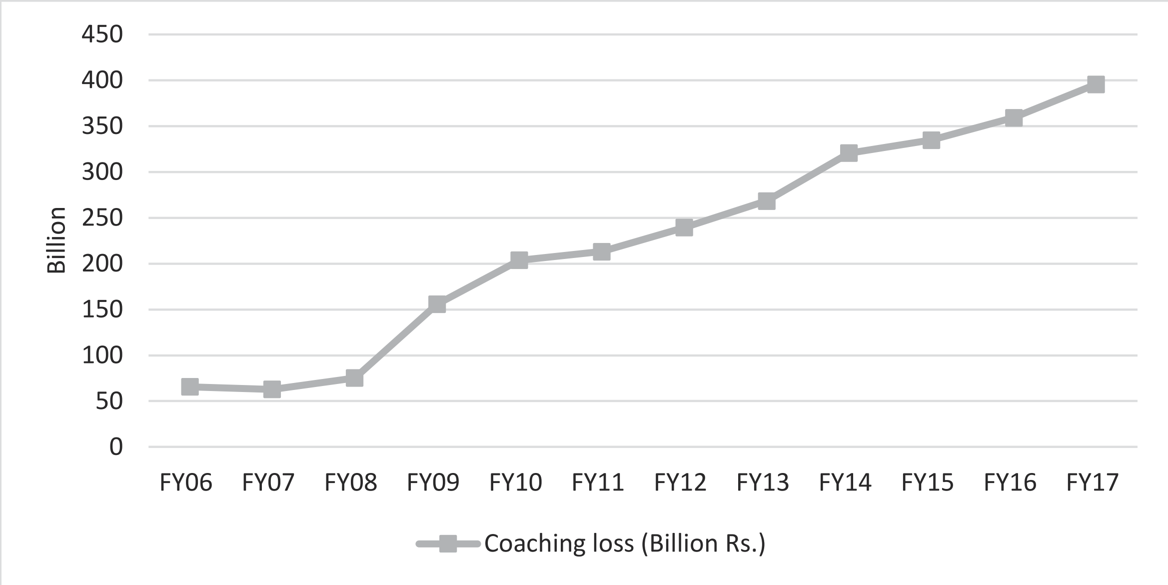
IR's accounting system is also structured to facilitate government control and does not follow the standard accounting system of a commercial entity. Various expert committees have found IR's accounting system as unsatisfactory and urged reforms (National Transport Development Policy Committee, 2014). For example, the cost structure for passenger versus freight services is opaque. Ordinary working expenses are reported as shared costs between passengers and freight despite the fact that passenger services expenses are higher due to factors such as safety standards, utilisation of stations, and staff requirement, etc. These capital expenses are often not built into passenger fares.

1.3 Social obligation of Indian Railways

IR operates a shared network that carries both freight and passengers. Its passenger volume (PKms) is the highest in the world (International Union of Railways, 2015), while freight carried by rail has declined in terms of its share in logistics from 86 per cent in FY 1951 to 30 per cent in FY 2016 (National Council of Applied Economic Research, 2016). A focus on passengers is part of a broader policy that has kept IR as not just a transportation option in a competitive landscape but one that "knits the country together", provides employment (the largest civilian employer in India), and is also a recipient of measurable patronage, with discounts across dozens of categories of passengers. Also added to this are the non-remunerative fares that ostensibly cover only 57 per cent of fare on average—a fact proclaimed on all passenger tickets. Figure 6 shows the trend of "coaching loss" (losses on passengers) reported by IR over the past 11 years.

> The current business structure of Indian railways is such that freight revenue cross-subsidises loss-making passenger traffic at an operational level. Freight bears a disproportionate burden of IR's cost structure, and much of this borne by coal.

Figure 6: Trend of coaching loss reported by IR



Source: IR Year Book (FY 2006-17).

The flipside of low passenger fares has been that IR over-charges almost all freight in the form of an explicit cross-subsidy based on item carried ("class" of the goods). Even this cross-subsidy, reported as coaching loss by IR, appears to be on the basis of cost-apportionment that is not only opaque but likely a simplified pro-rata assumption of cost allocations. While the weight on tracks is certainly higher from a loaded freight wagon than a passenger coach, many wagons return empty; and the manpower and safety and logistics costs for passengers, including with stops at many stations along the way, is far higher.

The cost structure of IR might be even worse

The rail network is shared between passengers and freight and each should be viable (World Bank, 2011). However, the current business structure of IR is such that freight revenue cross-subsidises loss-making passenger traffic at an operational level, and freight bears a disproportionate burden of IR's cost structure.

IR freight tariffs are much higher than global standards. An absolute comparison is incorrect due to purchasing power parity (PPP) differences, so a better metric is the fare-to-freight ratio (a globally accepted indicator to represent the passenger vs freight tariff). India's fare-to-freight ratio is around 0.24, which is substantially lower than the global standards of 0.7 to 1.9 (Railway Board, 2009). Data from a few countries is shown in Table 2 below.

Table 2: Ratio of average passenger fare to average freight fare for selected countries

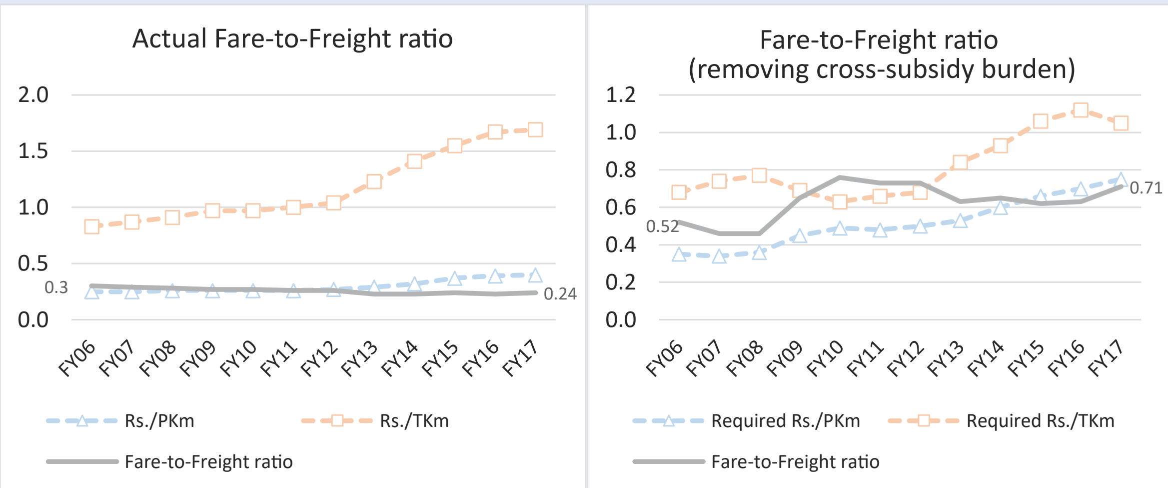
Country	Japan	Germany	Korea	France	China	Austria	Malaysia	Indonesia	Thailand
Fare-to-Freight ratio	1.9	1.5	1.4	1.3	1.2	1.1	0.9	0.9	0.7

Note: Estimates for the U.S. indicate a ratio of approximately 10.3, based on data from the US Statistical Abstract (United States Census Bureau, 2012).

Source: Railway Board, 2009; Planning Commission, 2010.

Figure 7 shows IR's historical fare-to-freight ratio from FY 2006 to FY 2017 along with the ratio after removing its coaching losses for the same time period, i.e., raising passenger fares and lowering freight rates.

Figure 7: IR's actual fare-to-freight ratio and after adjusting the coaching loss



Even after removing the coaching loss from the freight revenue and adding it to passenger revenue, the ratio increases to only 0.71, which is at the lower end of global values. This suggests that freight not only explicitly cross-subsidises passengers, it also bears a disproportionate burden of IR's cost structure.

2. Impact of railways on the power sector

IR plays an important role in electricity generation by transporting bulk coal to the power sector, and also to other sectors and industries. In FY 2017, out of 574 MT of coal consumed for grid electricity generation (Central Electricity Authority, 2017), 341 MT, or 60 per cent of it, was transported through railways (Railway Board, March 2017). This is a national average figure and includes imports, which are mostly coastal and thus don't often use railways; the domestic-coal-only share carried by railways is higher.

The variable cost of power generated through coal depends on the delivered price of coal and the efficiency of its conversion into power. This is the deciding factor for ranking power plants in the load despatch economic merit order. A high variable cost of electricity generation means the plant will be ranked among the last in merit order-based electricity procurement by distribution companies (DisComs).

The delivered price of coal to thermal power plants has three components: price of coal, levies and royalties, and transportation—roughly in the ratio of 40:25:35.[7] This makes railways a significant part of the coal supply chain to thermal power plants in India. It is worth emphasising that this is a national average, including pithead stations that have zero IR cost. Distant power plants reliant on railways may face triple the transportation costs.

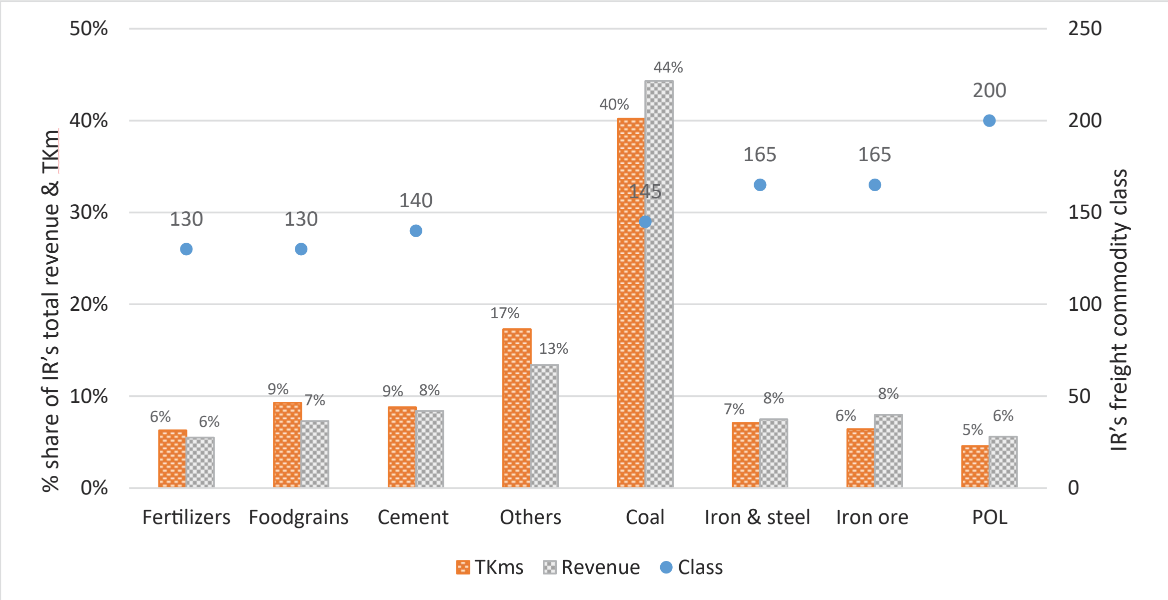
2.1 Indian Railways' coal freight rates

Indian Railways' freight rates are based on a "class system". It has 25 groups of commodities that cover almost all the commodities carried and has 16 freight rate classes (Indian Railway Conference Association, 2015). Class 100 is anchored as the break-even class and any class above that will have a proportionately higher freight rate as per the class.[8] Railways currently charge coal as per class 145, which means the freight rate for coal is 45 per cent higher than the commodity in class 100 for the same distance. Figure 8 shows the class of a few commodities and their respective revenue and TKms for FY 2016.

[7] Brookings India internal estimates; notified prices alone for coal run of mine, aka pithead, are lower, but some fraction of coal comes at a higher cost, e.g., via e-auctions. This varies over time.

[8] Figure 8 shows commodities like fertilisers and foodgrain are charged in class 130 and cement in class 140 but for all the commodities the percentage share of TKms is more than the percentage share of revenue. This means class 100 is no longer the breakeven class and needs to be re-calibrated.

Figure 8: IR's freight class of major commodities and their respective revenue and TKms for FY 2016



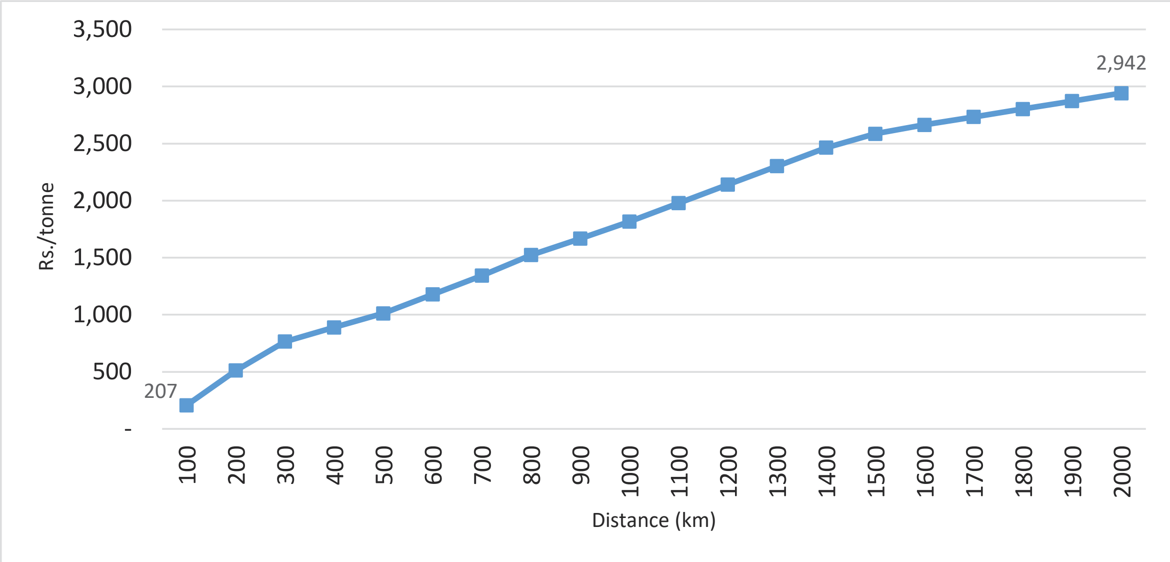
Note: Others is the balance across multiple classes. These are the actual revenues calculated from detailed per commodity revenues, and not a simple multiplication of rates by TKm. This, thus, factors in add-on charges for coal like load/unloading charges, busy season surcharge, etc. Petroleum, oil, and lubricants (POL) are the most expensive products.

Source: IR annual statistical statements and freight circulars.

Assuming a notional power plant with a specific coal consumption of 0.63 kg/kWh (average value for mid 2016) located at varying distances between 100 km and 2,000 km from coal mines, the transportation cost of coal by railways per unit of electricity generated is as low as Rs. 0.13/kWh for 100 km and as high as Rs. 1.85/kWh for 2,000 km.[9]

[9] IR net freight rate includes base freight rate for the distance travelled, a busy season surcharge of 15 per cent applied on base freight rate, a development charge of 5 per cent applied on base freight rate and a 5 per cent Goods and Services Tax (GST) applied on the sum. For details, refer to Appendix 1.

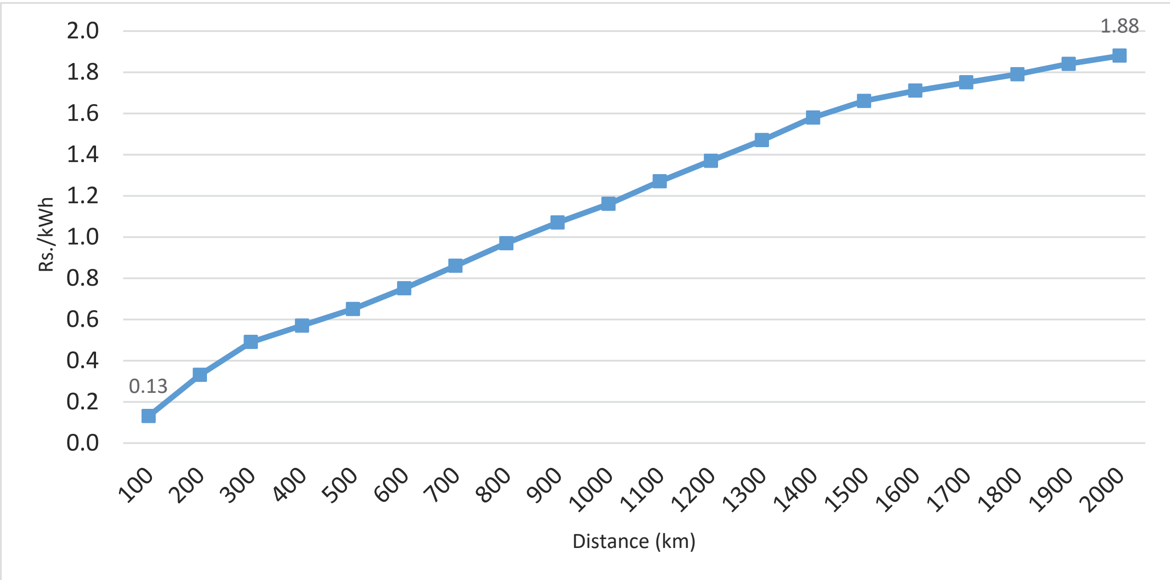
Figure 9: IR's coal freight rates per tonne in FY 2017



Note: Freight rate for coal as shown includes busy season surcharge (15 per cent), development charge (5 per cent), coal terminal charge (Rs. 110 per tonne) and GST (5 per cent).

Source: IR freight circular for coal applicable on August 24, 2016.

Figure 10: IR's freight rate per tonne for coal propagated to electricity (Rs. /kWh)

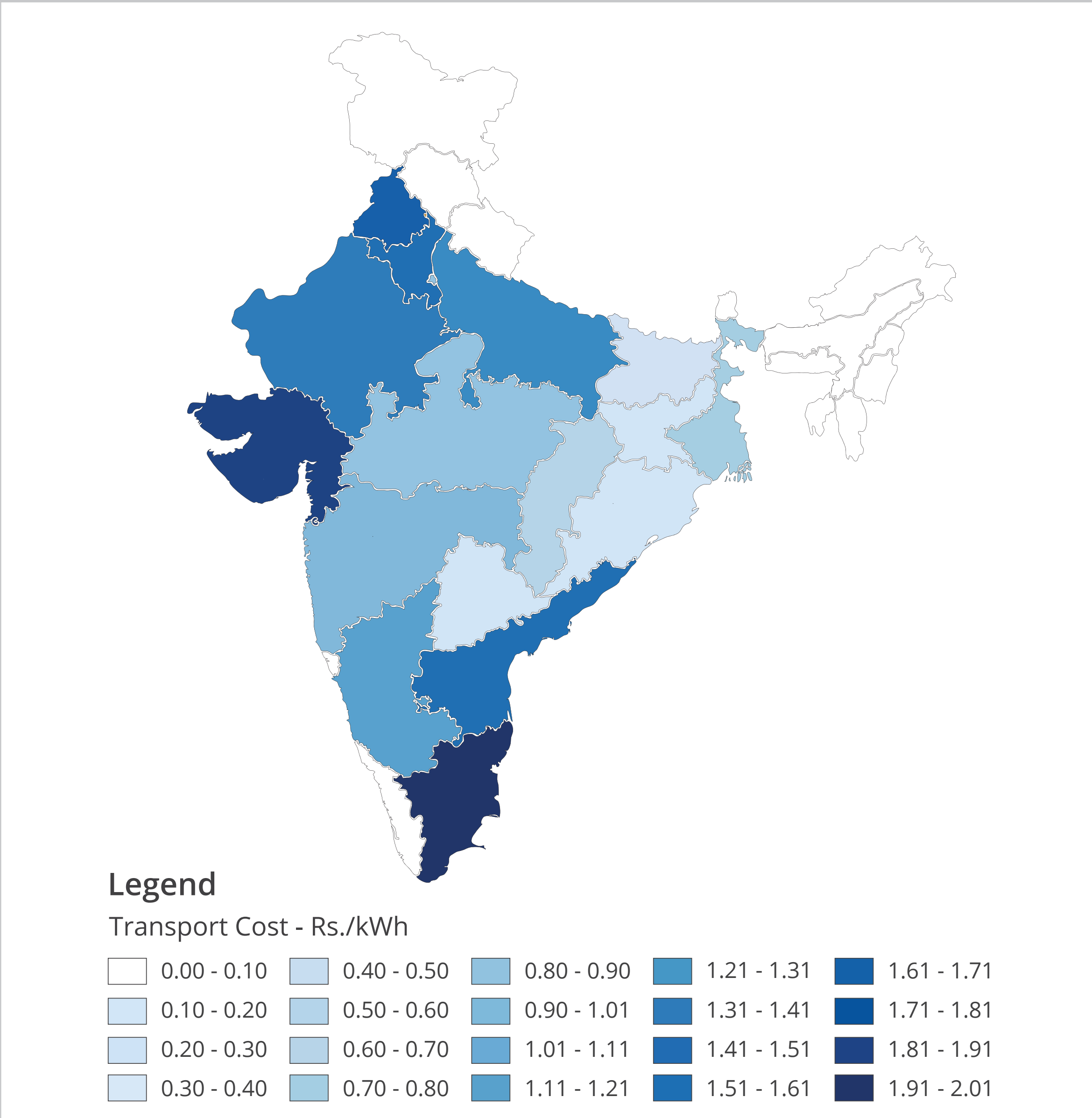


Note: This assumes a specific coal consumption of 0.63 kg/kWh.

Source: IR freight circular for coal applicable on August 24, 2016.

Figure 9 and Figure 10 show railways freight rates for coal per tonne that are reflected in per kWh of electricity generated from such coal. This means that coal transportation costs are a substantial part of the variable cost of electricity generation in power plants that are located at a distance as high as 1,500 km or more in states like Haryana, Punjab, Gujarat and Tamil Nadu. Figure 11 shows an indicative range of per kWh transportation cost for various states in India. The map does not reflect the weighted average cost for a given state[10] but only isolates the likely transportation costs based upon the assumption of identical specific coal consumption of a single power plant located in a particular state.

Figure 11: State-wise indicative range of per kWh transportation cost (FY 2017)



Note: White means either no coal power plants or no transportation via railways. Map is not to scale.
Source: Brookings India analysis.

[10] Refer to Appendix 2 for details of power plants selected.

2.2 Impact of coaching loss in cost of electricity generation

Three-quarters of electricity in India comes from coal, which is also the single-largest freight earner for Indian Railways. Freight, as noted earlier in the paper, pays for passengers– every unit (kilowatt-hour, or kWh) of power consumed pays for railway passengers. In FY 2017, railways reported a coaching loss of Rs. 395.65 billion (Railway Board, 2018) which essentially was recovered by overcharging the freight traffic. Table 3 shows this coaching loss distributed in the proportion of TKms of coal traffic to TPPs and its impact reflected in per unit of electricity generated in FY 2017 (based on average power plant efficiencies and specific coal consumptions, which factor in grades of coal).

Table 3: FY 2017 electricity generation and coaching loss share reflected in per unit electricity terms

Electricity generated in FY17	Coal transported through railways	Total coal-based electricity	Total generation (all sources)
Billion units (BUs) electricity in FY17	550	865	1149
Rs./kWh overpayment by coal going to power plants	Rs. 0.21/kWh	Rs. 0.14/kWh	Rs. 0.10/kWh

Note: These are calculated on different bases spanning all electricity, all coal-based electricity, and coal-based electricity carried by railways. If we take the base as electricity consumed, then the per unit cost would rise, as a measurable fraction of generation is not consumed due to technical and commercial losses.

Source: Calculated from Central Electricity Authority data and Brookings India analysis for railways.

The numbers mentioned above are representative of the national average but will vary by location. States like Gujarat, Punjab, Tamil Nadu that are far from coal mines, and therefore pay more than others, will contribute proportionately more to recover the coaching loss, i.e., the passenger subsidy. This overpayment by coal-based power applies to all coal generation in states like Punjab as all their coal comes via railways. A second layer of cross-subsidies is important to acknowledge in that of the over-payment for passengers isn't borne equally by all electricity consumers. Given that commercial and industrial (C&I) consumers cross-subsidise many other segments of power consumers, this burden likely to come disproportionally on such C&I consumers. Hence, depending on the electricity cross-subsidy structure, this railways burden on C&I might even be perhaps 30 per cent higher!

A flipside of this structure is a separate policy choice on how to improve the cross-subsidy structure if the intent is to improve C&I electricity costs to increase economic growth and employment. If there was a magic wand to eliminate the cross-subsidy by freight to passengers (or, more likely, a combination of options including slight passenger fare rises, efficiency gains, and a subvention – see Section 7), how should one spread this around? For example, the state's "overpayment" for passengers is Rs. 0.40/kWh of total generation in the state, one option would be to reduce all electricity consumers' prices by Rs. 0.40. Instead, policy-makers may want to pass on more of these offsets to the overpaying C&I as a mechanism to reduce the electricity cross-subsidy.

3. Will coal's future be any different than the past?

3.1 Brookings India analysis of coal demand

According to a Brookings India bottom-up coal demand model,[11] the future growth rate of coal demand in India is expected to be less than the historical rates. This model estimates coal demand for electricity generation as well as for industries. From a total of 574 MT of coal consumed for grid electricity (domestic and imported) in FY 2017, coal demand in FY 2030 may grow by 3.2 per cent CAGR to 865 MT under a moderate scenario of electricity demand and capacity addition in non-fossil sources assuming a 7 per cent gross domestic product (GDP) growth rate. In contrast, from FY 2006-FY 2017, coal consumption for grid electricity generation grew at 6.7 per cent CAGR.[12]

The projected decrease in coal tonne CAGR is based on the following factors:

- *Relatively slow electricity demand growth:* Overall electricity demand growth rates have slowed down, despite some volatility. This is mostly because of sectoral shifts in GDP (rising services), improvement in consumption efficiency, improvement in transmission and distribution (T&D) losses and semi-saturation in certain demand sectors.[13]

- *High RE penetration:* Renewable energy's share in gross power is likely to grow from roughly 6.6 per cent in FY 2017 to over 22 per cent in FY 2030 if India continues to increase its RE capacity at the current rate.[14] Given that RE is prioritised by the load despatcher, this will replace coal generation, reducing its share in net generation from 74 per cent in FY 2017 to 62 per cent in FY 2030.

- *Improved power plant efficiencies and enhanced role for super-critical plants:* The power capacity mix is modelled to change from 158 Gigawatts or GW (82 per cent) of sub-critical and 34 GW (18 per cent) of super-critical in FY 2017 to 143 GW (55 per cent) and 104 (40 per cent), respectively, and a small mix (15 GW) of ultra super-critical plants. Not only will the capacity mix change but the respective generation efficiencies of sub-critical, super-critical and ultra super-critical will change as well to 34 per cent, 37.5 per cent and 41 per cent, respectively. This will further lead to improvement in specific coal consumption from 0.63kg/kWh in FY 2017 to perhaps 0.57kg/kWh in FY 2030.

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[11] Brookings India's analysis, "Electricity Demand and Supply in India, 2030", by Mohd. Sahil Ali (forthcoming).

[12] Coal consumption for grid electricity generation is taken from CEA's executive summary report of March, 2012 (Table J of "Highlights of Power Sector")

[13] The Brookings India analysis includes new uses like electric vehicles and assumes modest headway towards expanded manufacturing under the Make in India initiative.

[14] The targeted 175 GW RE by FY 2022 would indicate an RE contribution of 19-20 per cent of generation, based on assump tions of overall demand growth. The Central Electricity Authority models scenarios where 175 GW takes longer to realise, one reason for a 22 per cent RE share projected in FY 2030 as a base calculation. Note that India does not include hydropower (except mini-hydel) under RE.

3.2 Location matters for railways

The slower-than-historical growth rate for coal demand in the country means a slow growth of coal traffic on railways even in the business-as-usual (BAU) scenario. IR coal traffic growth can be even slower because railways does not just depend on tonnes of coal demanded but its location as well. The following are the drivers that influence this, mostly negative:

- Not only will rising RE displace coal generation but its share will grow disproportionately in states with high solar and wind resources. These states also happen to be far from coal mines.

- For distant locations, the rise of high-voltage DC (HVDC) technologies has meant it can be cheaper and more efficient to send power over a wire than as coal by railways. The economics are further skewed due to coal cross-subsidising passengers. A back-of-the-envelope calculation suggests that the cost of a 1,800-km HVDC link would be about Rs. 0.39/kWh,[15] while railways freight tariff in FY 2017 for the same distance is Rs. 2,720/tonne, which, even if used in the most efficient super-critical plant, corresponds to Rs. 1.70/kWh transportation costs.

- High transportation costs raise the delivered price of coal, which means higher cost of electricity generation. This makes such power plants less competitive in the load despatch merit order, which leads to low PLFs, resulting in less coal requirement.

- Planned coal power plants' capacity is mostly either at or near coal mines, or distant and coastal (compared to today's country-wide distribution). The coastal plants are often designed for imported coal, which, while expensive per tonne, is still cheaper on a landed energy basis after factoring in the freight costs of railways and levies.

- State-owned power plants are geographically distributed all over the country compared to plants owned by NTPC Ltd. that are disproportionately pithead or near coal mines. Some of these state-owned power plants will be the first to be retired, not just because of age but also increasing costs of compliance with environmental norms for power plant emissions. All older plants are susceptible, but those that are state-owned and farther away are especially so.

[15] This estimate is based on a recent 1,830-km long 6,000-MW capacity 800-kV HVDC line that had a reported cost of Rs. 57 billion. This assumes a 50 per cent loading, 8 per cent technical losses, 12 per cent cost of capital (weighted average), and 4 per cent annual operational cost. Of course, adding a wagon or rake is much faster or easier than building a new HVDC transmission line, but adding a new railway track is even harder.

4. Future projections for coal and railways

IR has a de-facto monopoly for carrying bulk commodities such as coal over long distances, which means that any elasticity-based approach to project IR's future traffic for these may not be very useful. Equilibrium models similarly require a vast range of inputs with extensive uncertainty. We apply a parametric approach which estimates future traffic based on a range of different growth rate scenarios. We use a modelling platform, Analytica, which can simultaneously calculate n-dimensional space, allowing for a wide range for input values. It is worth emphasising that this model is parametric covering a wide base of possibilities, and no claim is made as to which scenario or range is likely to occur. Thus, in the absence of any specific analysis or drivers like shown for falling TKms for IR carried coal, we begin the base analysis with future trends similar to the past (FY 2006-17 trends).

4.1 Assumptions and modelling

Our model does not focus on IR's finances and accounting system but uses data from IR annual reports and audits to build a simple yet descriptive model. This model estimates future traffic, costs, and revenues of passengers and freight based on historical trends and future changes for a range of CAGRs, with an assumption that coaching losses as reported by IR are recovered by overcharging the freight traffic.

The calculations are based on a simple underlying series of the following premises:

1) Unless otherwise specified, freight and passengers continue at historical growths in volume, rates, and costs.

2) Costs are imputed based on "social welfare" or cross-subsidies, viz., overpayments by freight to offset low passenger rates. The "social obligations" component from the railways' accounts to passenger fares being as low as 43 per cent. As discussed previously, this may be conservative, given that this estimate is only based on ordinary working expenses.

3) We explicitly project future trends in volumes for both freight and passenger costs and revenues based on continuations of past trends and wide sensitivity analysis.

4) The underlying base assumption is that railways does not get any budgetary support to recover losses from passenger services and this policy will continue in the future as well. This analysis shows that such a policy may be unviable and budgetary support might be required in the future.

5) We assume that in the future, railways will not pay a dividend to the Government of India, in line with the recent shift.

6) The tariff to be charged for freight to keep railways profitable is the output of the

model, and is apportioned pro-rata across freight categories. Their relative share changes between FY 2017 and FY 2030 based on projected volumes and distances.

7) This aggregate cost is then converted into Rs./tonne for coal and Rs. /kWh for power.

While some of the cost-structure numbers appear to have growth rates that are high, and one could project lower inflation in the future, the flipside of lower inflation is a lower ability to raise nominal passenger fares or freights rates. In addition, examining year-on-year cost structures, wages and pensions jump periodically due to Pay Commissions which are decadal. Even if Pay Commissions are abolished, the average rise in wages may remain similar, albeit with a smoother progression.

4.2 Scenario for passenger traffic in 2030

4.2.1 Cost of passenger services

Indian Railways does not report the cost of passenger services in its accounting practices but instead reports the revenue from its passenger services as well as coaching losses that include losses from suburban traffic, non-suburban traffic, parcel traffic and uneconomic branch lines. For this model, we have assumed that the cost of passenger services is roughly represented by the summation of revenue from passenger services and coaching loss.

Cost of Passenger Services = Revenue from Passengers + Coaching Loss

Historically, the cost of passenger services has increased from Rs. 216.92 billion in FY 2006 to Rs. 858.45 billion. In FY 2017, with a CAGR of 13.3 per cent. The model calculates the cost of passenger services in FY 2030 for a range of CAGRs from 10-15 per cent with FY 2017 as base year.

4.2.2 Passenger kilometres (PKms) in 2030

The PKms in FY 2030 are calculated by assuming that passenger traffic grows at the same historical CAGR of 5.8 per cent (from FY 2006 to FY 2017), taking FY 2017 as the base year. While we recognise the future may not look like the past, it still presents a starting point for base calculations. The focus of the model is not to delve into the factors that may affect the future passenger traffic but rather into the impact of losses from coaching services on freight traffic.

4.2.3 Passenger revenue in 2030

As the revenue per PKm (fare) will determine the total revenue from passenger services in FY 2030 and is a policy choice, we have modelled it for a range of CAGRs from 4.5-12 per cent, taking FY 2017 as the base year, when the average fare was Rs. 0.40 per PKm. The historical (FY 2006-2017) CAGR for revenue per PKm was only 4.59 per cent. We have chosen to primarily focus on higher CAGRs as (1) railways is aware of the passenger revenue gap, and (2) any further growth in rate of coaching loss will be unsustainable in the future. This is despite a counter-recognition that inflation rates have come down, making nominal basis fare increases that much harder.

Table 4: Projected passenger fares in FY 2030 based on assumed CAGRs

Passenger fare CAGR (2017-2030)	4.5%	5.0%	5.5%	6.0%	6.5%	7.0%	7.5%	8.0%	9.0%	10.0%	11.0%	12.0%
Rs./PKm in 2030 (nominal rupees)	0.71	0.76	0.81	0.86	0.91	0.97	1.03	1.09	1.23	1.39	1.56	1.79
2030 Rs./PKm with 3% inflation correction	0.49	0.52	0.55	0.58	0.62	0.66	0.70	0.75	0.84	0.95	1.06	1.20
2030 Rs./PKm with 5% inflation correction	0.38	0.40	0.43	0.46	0.48	0.51	0.55	0.58	0.65	0.74	0.83	0.93

Note: In FY 2017, Rs./PKm was Rs. 0.40. From the nominal fares in FY 2030, we deflate these into real values using 3 per cent and 5 per cent inflation rates, which are representative for wholesale and consumer inflation rates.

4.3 Scenarios for freight traffic in 2030

4.3.1 Cost of freight services

Similar to the cost of passenger services, the cost of freight services is represented by removing the coaching losses from the total freight revenue reported by IR.

Cost of Freight Services = Revenue from Freight - Coaching Loss

Historically, the cost of freight services has increased from Rs. 297.21 billion in FY 2006 to Rs. 649.98 billion in FY 2017 with a CAGR of 7.4 per cent. The model calculates the cost of freight services in FY 2030 for a range of CAGRs from 5-9 per cent, with FY 2017 as base year. The starting variable is revenue from freight, which depends on freight tonnes, kilometres, and freight rate (Rs./TKm).

4.3.2 Freight tonne kilometres in 2030

Coal traffic to thermal power plants constitutes the biggest share in the IR freight traffic, both in terms of the volume and revenues. IR's future share of coal traffic to thermal power plants is directly dependent on the evolving demographics of the power sector in the country. Hence, to estimate freight TKms in FY 2030, we divide freight traffic into coal traffic going to thermal power plants, other coal traffic and other commodities traffic.

4.3.2.1 Coal traffic to thermal power plants

Based on the factors mentioned in Section 3.2, in the future, IR is not only going to lose a little share of coal traffic volume but also the average lead of coal traffic will further fall. But the rate of fall in average lead for thermal power plants will be slower than the historical rate as the historical reduction was also driven by a substantive one-time exercise of coal linkage rationalisation. Taking FY 2017 as the base year, the model estimates the coal TKms to thermal power plants for different combinations of fall in average lead and share of coal consumed for power generation in FY 2030.[16] Table 5 shows the TKms from coal traffic to power plants for various combinations of fall in average lead and share of power plant coal traffic.

Table 5: Projected TKms from coal traffic to power plants in FY 2030

2030; Coal Traffic to TPPs, TKMs (Million)		% fall in average lead of coal traffic to TPPs taking 496 km as base (FY17)			
		0%	**5%**	**10%**	**15%**
% share of coal consumption via IR in 2030	**60%**	220,806	211,974	203,142	194,309
	56%	206,445	198,187	189,929	181,671
	52%	192,083	184,400	176,717	169,033

Note: In FY 2017, IR transported 169,331 million TKms of coal traffic to thermal power plants i.e. 341 MT of coal (59 per cent of 574 MT; coal consumed for grid electricity generation excluding captive generation). Over an average lead of 496 km.

4.3.2.2 Other coal and other commodities traffic

To estimate the TKms from other coal traffic (not to thermal power plants) and from other commodities, the model used a CAGR-based multiplier. The model calculates the TKms from other coal and commodities in future by using a multiplier (0.95 to 1.05) on the historical CAGR from FY 2006 to FY 2017 taking FY 2017 as a base, which was 5.4 per cent for other coal traffic and 3.0 per cent for other commodities traffic. Table 6 summarises the results for the selected multipliers.

Table 6: Projected TKms of other coal traffic and other commodities traffic in FY 2030 for selected multipliers

Tonne kilometres (million)	2006	2006	CAGR	2030 (0.95×CAGR)	2030 (1×CAGR)	2030 (1.05×CAGR)
Other coal	42,877	76,075	5.4%	142,318	149,808	157,299
Other commodities	269,156	374,732	3.0%	526,370	554,074	581,778

Source: IR annual statistical statements and Brookings India analysis.

[16] Brookings India analysis, "Electricity Demand and Supply, 2030", by Mohd. Sahil Ali (forthcoming).

4.4 Assumptions for base scenario

From all the scenarios listed above for passenger and freight traffic in FY 2030, a set of assumptions is taken as the base scenario for an illustrative exercise. The assumptions for this base scenario are based on historical trends and the recent changes. However, these may not be true in future. The assumptions for a GDP growth rate of 7 per cent at mid-energy efficiency and mid-RE scenario are listed below:

Table 7: Assumptions for various parameters for projecting the base scenario

Parameter	Historical (2006-2017)	Projected (2017-2030)	Rationale
Cost of passenger services	CAGR – 13.3%	CAGR 13.0%	In the order of historical CAGR; mild improvement
Cost of freight services	CAGR – 7.4%	CAGR 7.0%	In the order of historical CAGR; mild improvement
Passenger kilometres (PKms)	CAGR – 5.8%	CAGR 5.8%	Same as historical CAGR
Average lead for coal to power plants	496 km in 2017	446 km in 2030	10% fall from 2017 number
Volume of coal traffic to power plants via IR[18]	59% in 2017 (341 MT out of 574 MT),	56% in 2030 (485 MT out of 865 MT[19])	Slight decrease for the reasons listed in section 4.1
Other coal traffic (TKms)	CAGR – 5.4%	CAGR – 1.05 × 5.4%	Improvement in industry and manufacturing due to government push
Other commodity traffic (TKms)	CAGR – 3.0%	Base – 1.05 × 3.0%	Improvement in industry and manufacturing due to government push

17 As a share of total coal consumption for grid electricity generation.
18 Brookings India analysis, "Electricity Demand and Supply in India, 2030", by Mohd. Sahil Ali (forthcoming)

5. Findings: Furture burden on coal and electricity

Based on the assumptions of base scenario, the projections for passenger and freight traffic segments are summarised in this section.

5.1 Passenger traffic projections

The cost of passenger services and PKms are calculated for IR in FY 2030 based on the base assumptions. Table 8 shows the projections for passenger traffic in FY 2030.

Table 8: Projected cost and PKms of passenger services in FY 2030 for base scenario

2030	CAGR (2017-2030)	Base scenario (2030)
Cost of passenger services (Billion)	13%	Rs. 4,205
PKms (Million)	5.8%	24,060

Note: Costs are in nominal rupees.

5.2 Freight traffic projections

Similarly, the cost of overall freight services is calculated in FY 2030 based on likely scenarios. However, the projection for freight TKms is divided into coal traffic to thermal power plants, other coal traffic and other commodities traffic. Table 9 shows the projections for the freight traffic in FY 2030.

Table 9: Projected cost and TKms of freight services in FY 2030 for base scenario

2030	CAGR (2017-2030)	Base scenario
Cost of total freight services (Billion)	7.0%	Rs. 1,566
TKms coal traffic to power plants (Million)	1.9%	189,929
TKms other coal traffic (Million)	5.8%	157,299
TKms other commodities traffic (Million)	3.4%	581,778

Note: Coal to power plants TKms assume a fall in average lead of 10 per cent and 56 per cent of total power sector coal carried by railways.

The model also projects the freight demand in the short-run till FY 2022. The projected CAGR (1.1 per cent) of coal TKMs to power plants for FY 2022 is slower than the projected CAGR (1.9 per cent) for FY 2030. The slower growth in TKMs is due to the assumption that average lead is falling yet the tonnage share of total power sector coal carried by railways is maintained. We have assumed that the fall in average lead will be faster in initial years considering the ambitious target of RE addition by FY 2022 and an increasing share of pithead plants till FY 2022, i.e., of the 10 per cent fall in average lead till FY 2030 from the base year, 8 per cent will happen in first five years till FY 2022 and the rest in the remaining years till FY 2030. This is also an estimate that reflects shutting down a few tens of GW of older power plants to comply with environmental emissions norms. These are disproportionately distributed around India compared to being near coal mines.

5.3 Coaching loss projections

The coaching loss in FY 2030 is calculated by removing the revenue from passenger services from the total passenger traffic cost.

Coaching Loss = Total Passenger Traffic Cost - Passenger Revenue

The total traffic cost is calculated as a sum of the projected cost of passenger services and cost of total freight services. The revenue from passenger traffic in FY 2030 depends on the rate of fare increase from the base year FY 2017. As increasing fare is a policy decision, we have calculated the coaching loss for various growth rates of increasing passenger fare Table 10.

Table 10: Projected coaching loss in FY 2022 and FY 2030 for various CAGRs of increase in passenger fares in the base scenario

CAGR (2017-2030) for passenger fare	Coaching loss in 2022 (Billion Rs. nominal)	Coaching loss in 2030 (Billion Rs. nominal)
4.5%	816	2,489
5.0%	797	2,379
5.5%	778	2,262
6.0%	759	2,139
6.5%	739	2,009
7.0%	719	1,871
7.5%	699	1,725
8.0%	678	1,571
9.0%	636	1,236
10.0%	592	862
11.0%	546	444
12.0%	498	-21

Note: This uses FY 2017 as a base year. For comparison, the coaching loss in FY 2017 was Rs. 395.65 billion.

Note that this is the aggregate passenger increase, without any specifications on how this is to be spread among types of passenger classes of service. Given that lower-class fares are disproportionately low (the 43 per cent subsidy is the average for passengers), that would be the segment to raise fares the most (in relative terms). However, that may also be politically the most challenging policy decision. On the other hand, even if higher-fare consumers (AC and higher) represent a higher ability to pay, there is also a risk they may shift to alternative transport, either buses or air. The government's UDAN scheme, to encourage air connectivity to smaller towns, amplifies this risk.

5.4 Freight revenue projections

The total freight revenue required to balance IR's cost structure is the main output of the model and depends on the revenue from passenger services for different growth rates of increase in the fare from the base year FY 2017, and the corresponding coaching loss. The total freight revenue is divided into revenue from coal traffic to power plants, other coal traffic and commodities traffic based on the historical share adjusted for the change in the historical and projected CAGR of the TKms for all the three categories. Table 11 shows the modelled projected revenue for all three categories of freight traffic in FY 2030 for the different growth rates of increase in passenger fares from the base year FY 2017.

Total Freight Revenue = Passenger Revenue + Coaching Loss

Table 11: Projected required revenue from freight categories in FY 2030 for various growth rates of passenger fare in the base scenario

CAGR (2017-2030) for passenger fare	Revenue from coal traffic to power plants (Billion Rs.)	Revenue from other coal traffic (Billion Rs.)	Revenue from other commodities traffic (Billion Rs.)	Total freight revenue (Billion Rs.)
4.5%	1,080	696	2,279	4,055
5.0%	1,053	675	2,217	3,945
5.5%	1,024	653	2,152	3,829
6.0%	994	629	2,082	3,706
6.5%	962	605	2,009	3,575
7.0%	928	578	1,931	3,437
7.5%	892	551	1,849	3,292
8.0%	854	521	1,762	3,137
9.0%	772	457	1,573	2,802
10.0%	680	386	1,362	2,428
11.0%	577	307	1,127	2,011
12.0%	463	218	864	1,545

Note: Historical passenger fare CAGR (FY 2006-2017) was 4.59 per cent.

From the power plant coal revenue (which was a working backward calculation), we can project the Rs./tonne freight cost for coal going to power plants, which leads us to a cost structure of Rs./kWh as shown in Table 12. This shows nominal FY 2030 costs as well as deflating by 3.5 per cent (possible wholesale inflation).[19] In comparison, the Rs. /kWh transportation cost of coal freight in FY 2017 was Rs. 0.57/kWh spread across electricity

[19] While 3.5 per cent as WPI may seem low on a long-term basis, any higher inflation would also increase cost structures. This WPI was chosen to also reflect the fact that for any range chosen, there is a spread between WPI and IR cost structures of several per cent.

generated from coal carried by railways, Rs. 0.36/kWh spread across total coal-based electricity and Rs. 0.27/kWh spread across all electricity generated and coaching loss of Rs. 0.21/kWh, Rs. 0.14/kWh and Rs. 0.10/kWh respectively. If we normalise based on electricity consumed or sold, the figure becomes higher, as a measurable fraction of generation is lost along the way (technical and "commercial" losses). Carried by railways, Rs. 0.36/kWh spread across total coal-based electricity and Rs. 0.27/kWh spread across all electricity generated and coaching loss of Rs. 0.21/kWh, Rs. 0.14/kWh and Rs. 0.10/kWh respectively. If we normalise based on electricity consumed or sold, the figure becomes higher, as a measurable fraction of generation is lost along the way (technical and "commercial" losses).

Table 12: Projected national average Rs./kWh coal transportation cost and coaching loss in FY 2030 for various growth rates of passenger fare in the base scenario

Passenger fare CAGR (2017-2030)	Rs./kWh coal transportation cost in 2030			Rs./kWh coaching loss in 2030		
	For grid electricity from coal carried on IR	For total coal-based grid electricity	For total grid-based electricity	For grid electricity from coal carried on IR	For total coal-based grid electricity	For total grid-based electricity
4.50%	0.96	0.54	0.32	0.54	0.30	0.18
5.00%	0.93	0.52	0.31	0.52	0.29	0.17
5.50%	0.91	0.51	0.30	0.49	0.28	0.16
6.00%	0.88	0.49	0.29	0.47	0.26	0.16
6.50%	0.85	0.48	0.28	0.44	0.25	0.15
7.00%	0.82	0.46	0.27	0.41	0.23	0.14
7.50%	0.79	0.44	0.26	0.38	0.21	0.13
8.00%	0.76	0.42	0.25	0.34	0.19	0.11
9.00%	0.68	0.38	0.23	0.27	0.15	0.09
10.00%	0.60	0.34	0.20	0.19	0.11	0.06
11.00%	0.51	0.29	0.17	0.10	0.05	0.03
12.00%	0.41	0.23	0.14	0.00	0.00	0.00

Note: The numbers shown are for FY 2017 real rupees (deflated @3.5 per cent, close to the recent wholesale inflation rate).

As we see, in real terms, the burden for coaching loss borne by electricity increases by about 2.5 times by FY 2030, assuming passenger fares only grow at historical (low) rates. While the numbers look smaller, when we normalise over a large base (total electricity), this is not appropriate. As Figure 11 shows, actual implications depend on where you are located. It becomes worse where you are more reliant on coal. Thus, in FY 2030, a state like Punjab may be paying some Rs. 1.5/kWh in FY 2017 real terms towards passengers for every kWh of coal-based generation in the state.

Table 13: Required CAGR of freight rate till FY 2030 to match the revenue requirement in the base scenario

2030		Passenger Fare (Rs./PKm) CAGR											
		4.5%	5.0%	5.5%	6.0%	6.5%	7.0%	7.5%	8.0%	9.0%	10.0%	11.0%	12.0%
Required Rs./TKms	Coal traffic to TPPs	7.96%	7.75%	7.52%	7.27%	7.00%	6.71%	6.39%	6.03%	5.21%	4.18%	2.88%	1.15%
	Other coal traffic	6.51%	6.26%	5.98%	5.69%	5.36%	5.00%	4.61%	4.17%	3.12%	1.79%	0.00%	-2.58%
	Other comm-odities traffic	7.33%	7.11%	6.86%	6.59%	6.30%	5.98%	5.62%	5.23%	4.32%	3.17%	1.67%	-0.38%
	IR total freight	7.36%	7.13%	6.89%	6.62%	6.33%	6.00%	5.65%	5.26%	4.35%	3.21%	1.72%	-0.32%

Note: Calculating backward, if the coal freight rate continues to rise at the same rate as in the past ("only" 7.5 per cent) then either passenger fares have to rise more than 5.5 per cent (versus 4.59 per cent historically) or railways finances don't break-even any more. Even this continued growth of coal freight rates seem untenable.

5.5 The future unlikely to be a continuation of the past

We note in Table 12 that if passenger fares increase at a high enough rate, we move to a zero cross-subsidy world. Note that these subsidies are as calculated, and it is conceivable many things can change. If one had to speculate based on trends, there is a chance that roads may accelerate their growth relative to railways, thanks to factors such as disproportional investments in roads compared to railways—approximately Rs. 4,500 billion was allocated on roads vs. Rs. 2,500 billion on railways in the 11th Five-Year Plan (2007-12) (Parvez Akhtar Qazi, 2017)—and GST, which increases regional warehousing optimised for trucking. High prices have already hurt IR, e.g., oil and petroleum products being priced as class 200 accelerated the move towards pipelines.

Prices are obviously a major bottleneck for growth of railways freight, and we do not expect the past trend of raising tariffs disproportionately higher to sustain, e.g., FY 2012-17 coal freight rates grew four times wholesale price index (WPI). What is not modelled is a likely feedback loop where higher prices lead to lower tonne-kilometres of freight carried. These are kept as parametric variables only.

As the analysis indicates, the entire model of IR keeping afloat on the back of coal will need a revamp. Leaving aside their political unlikelihood, increases in passenger fares as shown in Table 14 will still not cover the underlying cost structure challenges.

A big concern is that IR's costs are rising at a faster pace than total fares, so the passenger cross-subsidy burden on freight is rising. Shouldn't the cost structure come down in the future with possible falling inflation and higher efficiency? While efficiency gains are helpful and targeted, IR has also underinvested in new services, safety upgrades and modernisation, etc. These will hit costs in the coming years far more than the speed with which they will pay back in terms of efficiency. Added to that will be the challenge of raising fares for superior service.

The operating ratio (a measure of what it costs to earn one rupee of revenue in terms of operational expenses) worsened from 90.49 per cent in FY 2015-16 to 96.50 per cent in FY 2016-17, despite railways underfunding its pension obligations by Rs. 50 billion in FY 2016-17, as warned by the Central Auditor General (Comptroller and Auditor General of India, 2018). Railways also underfunded several other obligations such as debt servicing fund. The preliminary operating ratio figure for FY 2017-18 is reportedly even worse at 98.5 per cent, and may include similar underfunding.

A big concern is that IR's costs are rising at a faster pace than total fares, so the passenger cross-subsidy burden on freight is rising.

Workforce costs are now over 64 per cent of gross traffic revenues (FY 2017), and the decadal CAGRs for wages and pensions have been 13.9 per cent and 17.8 per cent,[20] respectively (Kumar, 2018). All employees hired before FY 2002 are eligible for defined pension plans—a major cost implication for the entire government, not just railways. The total number of employees has come down through attrition (3 per cent annual retirements are filled at a rate of only about 1 per cent (Rao, 2015)), but there are now a reported 244,819 vacancies, including 144,492 in the safety categories (Kumar, 2018), on a basis of about 1.3 million employees today.

[20] Informal discussions with railway experts.

This workforce productivity/efficiency improvement appears to be reaching a plateau due to not just workforce pushback, but concerns about safety. Safety could be maintained with mechanisation, a costly investment and one likely to meet union resistance. If we do true cost accounting, most of the workforce costs might be linked to passengers, but it is currently opaque as to how this cost is split between passengers and freight.

Table 14: Fare-to-freight ratio in FY 2030 for various combinations of growth in passenger fare and cost of passenger services

2030		CAGR of increase in cost of passenger services			
		9%	**11%**	**13%**	**15%**
CAGR of increase in passenger fare, Rs./PKm	**4.5%**	0.27	0.21	0.17	0.13
	5.0%	0.31	0.24	0.18	0.14
	5.5%	0.34	0.26	0.20	0.16
	6.0%	0.38	0.29	0.22	0.17
	6.5%	0.44	0.32	0.24	0.19
	7.0%	0.50	0.36	0.27	0.21
	7.5%	0.57	0.41	0.30	0.23
	8.0%	0.67	0.46	0.33	0.25
	9.0%	0.96	0.61	0.42	0.30
	10.0%	1.55	0.85	0.55	0.38
	11.0%	3.41	1.31	0.74	0.48
	12.0%	Negative	2.49	1.09	0.64

Note: These high passenger fare scenarios ostensible remove the coaching loss, but we still find fare-to-freight ratios remaining low versus global standards if passenger service costs rise. For comparison, the fare-to-freight ratio in FY 2017 was 0.24, and the historical CAGR (FY 2006-17) for cost of passenger services was 13.3 per cent.

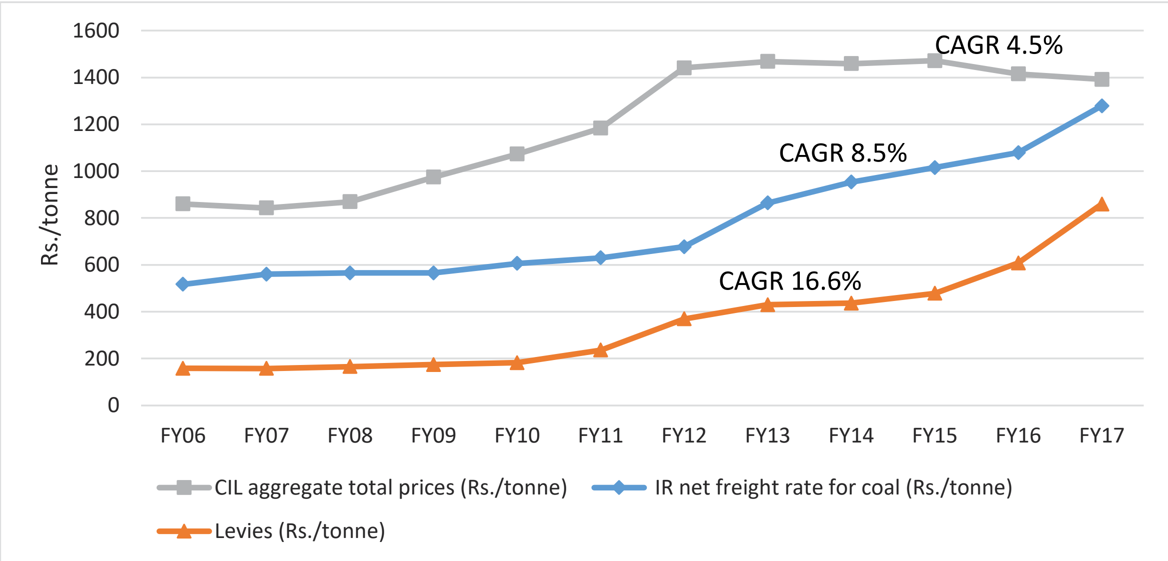
If we analyse the projected change in fare-to-freight ratio for FY 2030, we find that getting rid of the subsidy is not sufficient; the ratio still does not grow comparable to other countries (Table 14). This indicates the underlying cost structure as declared by IR and used as a base in the analysis which understates the extent of the cross-subsidy. To truly improve freight logistics costs and maintain global competitiveness, one may need a fare-to-freight ratio closer to one or even higher (given our high passenger usage). Without this, ambitions of the government's Make in India initiative and necessary employment growth may fail to materialise.

6. Other future prospects and issues

6.1 Delivered coal has three components, transport is just one of them

Delivered coal costs matter to all users. Some, like the cement industry, are able to switch to alternative fuels such as PETCoke, while power plants are often locked into a particular quality of coal. A power plant may try to switch to imports if possible and viable, but a more plausible scenario is where the state may reduce coal power overall as other forms of power become more competitive, especially RE.

Figure 12: Historical trend of IR net freight rate per tonne, levies per tonne and CIL aggregate total prices



Note: The CAGR is from FY 2006-17. This is for all types of coal, all users and modes of sale. Note that levies have dramatically risen in recent years, especially with the "coal cess". If we examine the CAGRs from FY 2012-17 only, the increases in transport costs and levies are measurably higher, and CIL's realised revenues actually decline. Also, for a notional non-pithead power plant using a average grade of coal, the delivered cost of coal comes to over Rs. 3,000 per tonne.

Source: Underlying data from IR's freight circulars for respective years and CIL's Annual Statement of Sales and Levies (Coal India Ltd., 2018).

Delivered coal price is a combination of Coal India Limited's (CIL) coal prices, levies, including royalty, coal cess etc., and transportation cost. Historically, levies[21] have grown at a much faster rate (CAGR 16.6 per cent) than IR's per tonne transportation charges[22] (CAGR 8.5 per cent) and CIL's sales per tonne[23] (4.5 per cent) (Figure 12). In fact, for the past five years, CIL's realised sales per tonne have remained virtually flat and actually decreased in the past two years, whereas the levies per tonne and transportation charges per tonne

[21] The levies per tonne are calculated from CIL's annual accounts statements by dividing total levies collected by total million tonnes offtake for that year. Levies include excise duty (now GST), royalty, cess on coal/clean energy, stowing excise duty, central and state sales tax (now GST), National Mineral Exploration Trust tax and District Mineral Foundation tax.

[22] IR net freight rate includes IR's base freight rate, busy season surcharge and development charge for a representative fixed distance of 611 km for all the years (chosen 611 km only because of the availability of time series freight rates).

[23] Sales per tonne is also calculated from CIL's annual accounts statements by dividing net sales by million tonnes offtake for that year.

have grown even faster than wholesale inflation. It is highly uncertain how levies are going to increase in the future but certainly the part of levies which is charged as a percentage of the coal price per tonne will increase with an increase in coal prices. The delivered price of coal is what matters for the end-user (power plant) and if railways continues to increase its freight charges at the same rate, it might lose its share of coal traffic to other modes, e.g. trucks for short distances, and HVDC transmission lines for longer distances.

While the Rs. 400-per-tonne cess appears a lot, in carbon terms it is modest (a few dollars per tonne only, varying by grade), and one cannot be certain what the medium- or longer-term future holds. Even if levies do not rise as much again, CIL is likely to need to increase prices for multiple reasons. A re-grading exercise found most coal, on average, was a lower grade than claimed ("grade slippage") and this has hurt CIL's revenues in FY 2017-18 (preliminary data). Periodic wage increases, especially linked to periodic Pay Commissions by the government, will raise costs. CIL's need to focus more on environmental and rehabilitation issues will also raise costs. In addition, as more coal is mined, the "lower hanging fruit" of easy coal comes first and stripping ratios (overburden removal) worsen over time.

Such issues place a backstop on how much leeway IR has in raising coal freight rates. IR's future pricing strategies must reflect not just its own pricing decisions but the ultimate delivered price of coal for end-users and DisComs, who may avoid coal altogether. This is before we worry about the longer term, when battery technologies may make RE competitive with baseload coal, heralding peak coal in India (a phenomenon China is reported to have already reached (Ye Qi, 2018)). Many industry watchers believe cheap batteries may emerge by or even before FY 2030. This is not a long timeframe from a railways' perspective, which deals in investments lasting many decades.

6.2 Can dedicated freight corridors help?

There are two major dedicated freight corridors (DFCs) under development, the Western, focusing on containers, and the Eastern, which focusses on coal. Examining their detailed project reports (DPRs) a very high fraction of the Eastern DFC's revenues (75-92 per cent) is projected to come from coal (Japan International Cooperation Agency, 2007). As we have shown, historical projections for growth of coal made at the time of the Detailed Project Reports may not hold in the future.

We also do not have any clarity on the tariff structure for DFCs. Will these continue to bear the subsidy-burden of passengers "as is" today, but offer enormous benefits in terms of freeing up congestion and offering faster times? There are estimates of efficiency gains of some 12x (combination of speed and tonnage that can be hauled; however, operational costs would also go up). What is completely unknown is whether DFCs would need to continue cross-subsidising passengers like today?

The creation of a separate Special Purpose Vehicle (SPV) for the DFCs suggests they want to avoid this, and garner revenues as a usage fee. The flipside is that the SPV then needs to cover all its costs through freight revenues. The high capital cost and projected loading imply freight costs, even with efficiency gains, are not sufficient to lower costs much, if at all. One reason is that this SPV covers all the costs of a new line, while new line costs are a small fraction for IR overall, where all services (goods and passengers) go over tracks mostly built decades ago, i.e., are spread over a large base that is mostly amortised.

6.3 Changing power grid: Need for flexibility

The Indian power grid is going through many changes with the increasing share of RE in electricity generation. In the old system, which was based on the costs-plus mechanisms passing through via a power purchase agreement (PPA), virtually all supply options were deterministic (despatchable), but wind and solar are variable.

> As growth in coal demand slows down thanks to cleaner sources of energy, improved efficiencies in power plants, etc., growth of coal freight will also slow down. Indian Railways, which depends heavily on coal to "subsidise" passengers, needs to plan for this future.

Added to that, the total requirement for coal also falls, impacting the PLFs. Much of the fall in PLFs in coal plants in recent years (from over 77 per cent in FY 2010 to around 60 per cent in FY 2018) is due to an overhang of capacity that grew at double the rate of electricity demand growth between FY 2012 and FY 2017. If PLFs fall, there is uncertainty over how much, how fast and where this may impact. With such uncertainty, who bears this risk? It is not just the power plant (which may attempt to offset the risk with a PPA, that covers fixed costs), but there is risk for railways as well, especially if it either invests expecting a certain growth or is reliant on a growth rate to make its finances viable.

U.S. experience suggests two possible trends that may impact railways. One, the rise of an integrated power grid with adequate transmission capacity means that as we have more competition, more power may be called from locations that are further off from the DisCom's perspective, i.e., not all generation need be within the state. We already see this with the rise of NTPC whose PLFs are more than 10 percentage points higher than average (Ministry of Power, 2018). This creates uncertainty for railways. Second, the rise of RE means more power will come from RE-rich locations, which happen to be, on average, at locations distant from coal. Both of these trends prefer a stronger national power grid than a system with power plants spread across the country reliant on railways to ship coal. Some coal is still needed, but less than before (in relative terms) and with higher uncertainty and variance.

A PPA-based mechanism is not a market-based system at an operational level, one-time bidding for power plants aside. The prices were set to be ‘viable’, and for thermal power plants, fixed versus variable costs were treated differently. In future, if India goes down the route of energy market for power, variable costs will dominate the attractiveness of any power source. This again impacts railways coal traffic as the electricity generation variable cost will be determined by the fuel transportation costs for different locations.

The need, therefore, is for more flexible contractual and financial instruments in the sector and for physical coordination that will lead to shorter timeframes. Planning is quarterly at best, or even annual, while imbalances can creep in a matter of days. When problems occur, there is a risk of a “blame game” between the stakeholders across power plants, railways, and CIL. Recently, as an example, the Chairman of CIL pointed out that, “the scarcity is not due to low coal production. Power plants must build up coal stock to cater to any sudden spurt in demand. We have on multiple forums asked the generators to build their stock level” (The Telegraph, 2018).

7. Possible policy choices for a viable future

Railways' financial model, like the power distribution (retail) sector, is based on a cost-plus model to earn sufficient revenues, combined with cross-subsidies between segments of users. For railways, not only do we have an enormous differentiation between freight and passengers, we have differences within these segments as well.

Such distortions are not ideal for signalling micro-economic efficiency (any underpriced good is likely to be overused) and they represent a specific risk for competitiveness. If coal is too expensive because it pays for passengers, then coal-based power becomes prematurely uncompetitive with renewable energy. In addition, trucking becomes far more competitive than would have been otherwise, with negative implications for foreign exchange (diesel imports) and the local environment.

7.1 Passenger fare and subvention support

The simple solution is to bring passenger fares and freight rates to align with true costs. This is easier said than done. If raising passenger fares is politically difficult, then railways may require explicit budgetary support for passengers to cover this "social obligation". Without it, the burden on freight will continue to grow as a sort of tax. Expensive freight has an adverse impact on industry and electricity competitiveness, thereby affecting economic growth and expansion of employment. Table 15 shows the sensitivity of CAGR of required total freight rate rise till FY 2022 for various combinations of passenger fare increase and subvention support.

Table 15: CAGR of required total freight rate till FY 2022 for various combinations of passenger fare increase and subvention support

2022		Subvention in 2022 (Billion Rs.)					
		0	**100**	**200**	**300**	**400**	**500**
Passenger fare CAGR (2017-22)	**4.5%**	6.72%	5.46%	4.13%	2.73%	1.25%	-0.33%
	5.0%	6.49%	5.22%	3.87%	2.46%	0.96%	-0.63%
	5.5%	6.26%	4.97%	3.61%	2.18%	0.67%	-0.94%
	6.0%	6.01%	4.71%	3.34%	1.90%	0.37%	-1.27%
	6.5%	5.76%	4.45%	3.07%	1.61%	0.06%	-1.60%
	7.0%	5.51%	4.18%	2.78%	1.30%	-0.27%	-1.94%
	7.5%	5.24%	3.90%	2.49%	0.99%	-0.60%	-2.30%
	8.0%	4.97%	3.62%	2.19%	0.67%	-0.94%	-2.66%
	9.0%	4.40%	3.02%	1.55%	0.00%	-1.66%	-3.44%
	10.0%	3.80%	2.38%	0.88%	-0.72%	-2.43%	-4.27%
	11.0%	3.16%	1.70%	0.16%	-1.49%	-3.25%	-5.16%
	12.0%	2.48%	0.98%	-0.61%	-2.31%	-4.14%	-6.12%

Note: Assuming cost of passenger service grows at a CAGR of 13 per cent. Historical CAGR of total freight rate rise was 6.7 per cent.

7.2 Operational costs

In addition to growing passenger revenues, railways can attempt to increase its productivity and efficiency, i.e., lower its cost structure. One aspect of savings is likely to come from its electrification, but some of the savings are not from electrification per se (a majority is already electrified in terms of TKms or PKms) but because of procurement efforts by IR to find cheaper electricity, including through solar power. While this may hold true cash-wise for IR, some of IR's savings breaks the electricity utility (DisCom) model of cross-subsidies by "paying customers" including IR to cover under-recovery by most households and all agriculture. Table 16 below is for an 11 per cent cost rise of passenger services.

Table 16: CAGR of required total freight rate till FY 2022 for various combinations of passenger fare increase and subvention support

2022		Subvention in 2022 (Billion Rs.)					
		0	100	200	300	400	500
Passenger fare CAGR (2017-22)	**4.5%**	5.00%	3.64%	2.22%	0.70%	-0.91%	-2.63%
	5.0%	4.75%	3.39%	1.94%	0.41%	-1.22%	-2.96%
	5.5%	4.50%	3.12%	1.66%	0.11%	-1.53%	-3.30%
	6.0%	4.24%	2.85%	1.37%	-0.19%	-1.86%	-3.66%
	6.5%	3.97%	2.56%	1.07%	-0.51%	-2.21%	-4.03%
	7.0%	3.70%	2.27%	0.76%	-0.84%	-2.56%	-4.41%
	7.5%	3.41%	1.97%	0.45%	-1.18%	-2.92%	-4.80%
	8.0%	3.12%	1.66%	0.12%	-1.53%	-3.30%	-5.21%
	9.0%	2.51%	1.02%	-0.57%	-2.27%	-4.09%	-6.07%
	10.0%	1.86%	0.33%	-1.31%	-3.06%	-4.95%	-7.00%
	11.0%	1.17%	-0.41%	-2.09%	-3.91%	-5.86%	-8.00%
	12.0%	0.43%	-1.20%	-2.94%	-4.82%	-6.85%	-9.09%

Note: Assuming cost of passenger service grows at a CAGR of 13 per cent.

While a fall from 13 per cent to 11 per cent passenger cost structure appears small, in relative terms it is about a 15 per cent improvement compared to business as usual (BAU). This is far easier to achieve in a longer time-frame such as FY 2030 instead of FY 2022. If the goal is to end freight overpayments by FY 2022, the efficiency gains and/or the passenger fare rises are likely to be unachievable, leaving a subvention as a necessary tool in the portfolio of change. Ideally, any limited subvention should be capped, and should diminish as passenger fare rises and efficiency gains continue. It is a larger discussion as to whether any such support should be a budgetary subvention to IR or payments for selected categories of consumers or a direct benefits transfer (DBT)-like mechanism for end-users (passengers) themselves.

Some savings are likely there, but sometimes politically hard to reach. Wages are an enormous share of costs, and "efficiency" may be rejected if it means reduction of jobs. Salary structures (and pension obligations) are not a direct choice of the railways. Some segmentation of railways may also help sharpen potential efficiency options – e.g., isolating suburban rail into separate companies, which are high volume but low fare, may help shield other passengers or even freight. Of course, "fixing" the rest of the system means addressing problem segments head on.

7.3 Freight infrastructure

The other option for IR is to improve its freight carriage. Multiple parliamentary standing committees and analysts have observed changes in freight trends and revenues with concern. The first need for IR is to be able to carry additional freight, which needs investment to overcome chokepoints and grow tracks and lines, as opposed to wagons. Discussions with end-users suggest that while freight charges are high, there are also other factors that discourage their use of IR for freight. Issues of first-mile/last-mile interconnectivity are obvious concerns. One partial solution is to use standardised shipments, pallets, containers, etc., that handle fixed (and medium-sized) loads in modular batches, instead of loading/unloading that occurs today at a gunny-bag scale. The last demand from end-users has been for improved performance. While faster delivery is always welcome, improved predictability in delivery can be a start.

In addition, railways has to come up with offerings that match consumer needs in terms of smaller scales. Coal and bulk commodities may easily work, but manufactured goods (finished products) or even component parts may not require more than a single wagon (or part wagon). A minimum sizing of required wagon load to avail IR's freight service means trucks are the only viable choice for many consumers even shipping products long distances. Improvements in highways and implementation of GST (with expected regional warehouses instead of per-state ones) suggest further competitiveness of trucks over rail. While railways is dependent on coal, power plants also rely on railways for delivery of coal. Bottlenecks in railways were reported (Sengupta, 2017) as the source of coal power plant woes in FY 2017-18. This appears to be a cyclic issue of stockpiles as well. The temporary solution announced in late FY 2017 has been to prioritise trucks for short-distance transport, which is more a reflection of choked capacity than something expected to change finances significantly.

7.4 Flexible contracting terms

The ecosystem relationship or chain is as follows:

Miner (CIL) ⟷ Railways ⟷ Power plant ⟷ DisCom

The present scenario is one of fixed contracts at notified prices (cost-plus) with an expectation of a certain volume (load factor or usage). Any perturbation or deviation will propagate, and it is not clear how adjustments in isolation can be sufficient. RE is growing rapidly, leading to a further fall in PLFs of power plants. Even if contractually PPAs cover the power plant fixed costs, they save fuel costs by avoiding coal from thermal plants. That impacts the volume for railways, and CIL. The catch is that the investment quantum and timeframes are highest for CIL and railways. It takes more than five years to develop a mine, another five to build a coal power plant, and much more time to build a new railway line. In contrast, adding a new solar plant can be done in perhaps a year (bidding and paperwork aside).

While it is speculative to suggest instruments to solve such issues, one can frame possible solutions across a spectrum of change. At one end, we allow propagation of risk and uncertainty. If something changes "downstream" they would have the rights to pass through such changes to their upstream entity. At another end, we end all propagation of risks via contracts and instead rely purely on market mechanisms to signal both price and quantity. Both are uncertain.

One could attempt to fix one parameter and let the market discover the other (price or quantity) but quantity is likely to be more important and inflexible for India. At a given price, if the quantities demanded (or supplied) are too low, this requires an adjustment of prices. It is far easier to consider quantities as being contracted, allowing prices to float. Ultimately, both prices and quantum should be subject to market forces. Railways and CIL have some but limited competition spanning HVDC (railways), RE, imports, etc. We don't have feedback mechanisms that align with time constants of investments. If global coal prices crash, other than power plants already set up for imports, how many can benefit from this? Do they have the technical means to use such coal? Do they have transportation linkages? The coal market is not very liquid (no pun intended). Policies must reflect such structural constraints instead of simply saying "market competition" which may not materialise or be effective.

As this analysis shows, the business as usual of passing on passenger fare under-recovery to freight and coal, that too in a manner that often raises prices multiple times inflation, is unsustainable. Is the solution raising passenger fares, or improving efficiency, or budgetary support? The best answer may be a combination of all of the above.

> The ratio in India of passenger fares vs freight charges is 0.24 – this is among the lowest in the world, showing how much freight overpays.

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Appendix 1: Implication of distance on electricity generation cost

Table 17: Net freight rate calculation over a distance of 2,000 km

Distance (km)	Freight rate as per distance slab (Rs./tonne)	Busy season surcharge @15%[25]	Develop-ment charge @5%	Terminal charges (loading unloading)	Total freight rate (Rs./tonne)	GST @5%	Total transpor-tation cost (Rs./tonne)	Specific coal consump-tion (kg/kwh)	Total transpo-rtation cost (Rs./kwh)
100	164.5	24.68	8.23	-	197.40	9.87	207.27	0.63	0.10
200	314.2	47.13	15.71	110	487.04	24.35	511.39	0.63	0.32
300	516.0	77.40	25.80	110	729.20	36.46	765.66	0.63	0.48
400	614.0	92.10	30.70	110	846.80	42.34	889.14	0.63	0.56
500	712.0	106.80	35.60	110	964.40	48.22	1,012.62	0.63	0.64
600	844.0	126.60	42.20	110	1,122.80	56.14	1,178.94	0.63	0.74
700	974.0	146.10	48.70	110	1,278.80	63.94	1,342.74	0.63	0.85
800	1,117.1	167.57	55.86	110	1,450.52	72.53	1,523.05	0.63	0.96
900	1,231.6	184.74	61.58	110	1,587.92	79.40	1,667.32	0.63	1.05
1,000	1,349.5	202.43	67.48	110	1,729.40	86.47	1,815.87	0.63	1.14
1,100	1,478.4	221.76	73.92	110	1,884.08	94.20	1,978.28	0.63	1.25
1,200	1,607.6	241.14	80.38	110	2,039.12	101.96	2,141.08	0.63	1.35
1,300	1,736.2	260.43	86.81	110	2,193.44	109.67	2,303.11	0.63	1.45
1,400	1,864.1	279.62	93.21	110	2,346.92	117.35	2,464.27	0.63	1.55
1,500	1,961.2	294.18	98.06	110	2,463.44	123.17	2,586.61	0.63	1.63
1,600	2,023.4	303.51	101.17	110	2,538.08	126.90	2,664.98	0.63	1.68
1,700	2,078.4	311.76	103.92	110	2,604.08	130.20	2,734.28	0.63	1.72
1,800	2,133.4	320.01	106.67	110	2,670.08	133.50	2,803.58	0.63	1.77
1,900	2,188.4	328.26	109.42	110	2,736.08	136.80	2,872.88	0.63	1.81
2,000	2,243.4	336.51	112.17	110	2,802.08	140.10	2,942.18	0.63	1.85

Note: Brookings India analysis. This is based on IR's freight circular for coal applicable on August 24, 2016 and the implications on electricity generation costs.

[24] Busy season surcharge was applied @15 per cent over the base fright rate for nine months a year. However, the values given in the table are applied @11.25 per cent, so that 15 per cent for nine months is equivalent to 11.25 per cent for 12 months.

Appendix 2: Selected power plants in respective states for generating the heat map

Table 18: Transportation costs for selected power plants in states across India

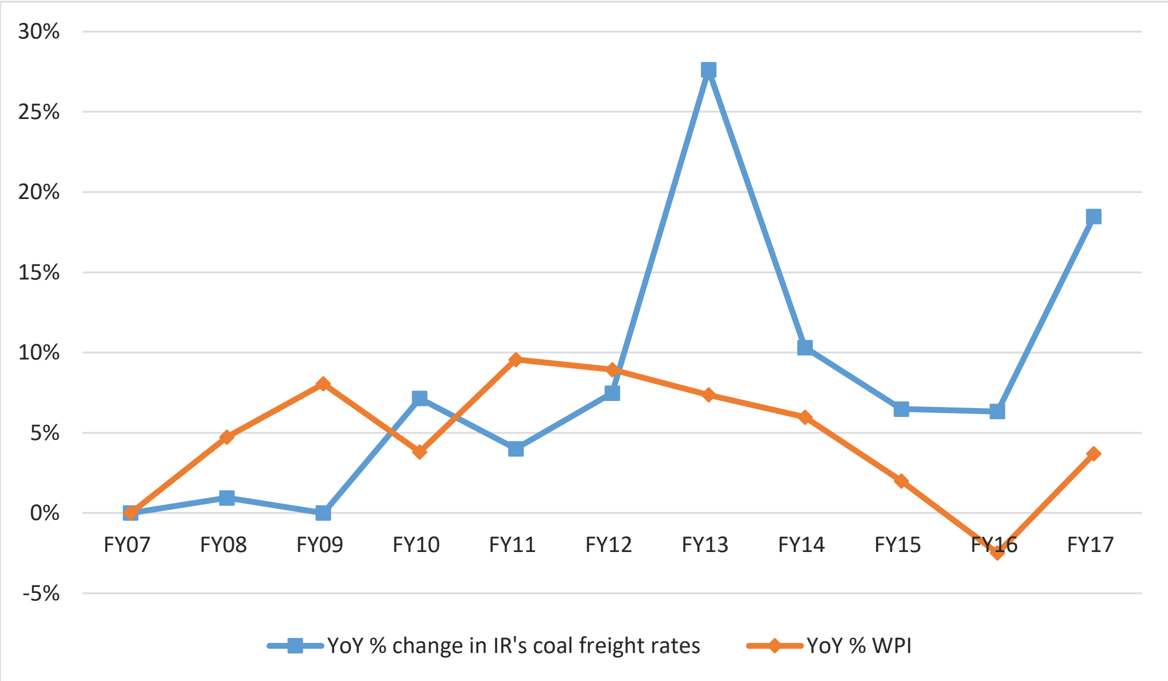
State	Power plant	Weighted average distance (km)	Net freight rate (Rs./tonne)	Transportation cost (Rs./kwh)
Tamil Nadu	Tuticorin TPS	2,491	3,289	2.10
Punjab	GH TPS (Leh.Moh.)	1,600	2,665	1.71
Gujarat	Gandhi Nagar TPS	1,530	2,616	1.67
Haryana	Rajiv Gandhi TPS	1,427	2,525	1.62
Andhra Pradesh	Damodram Sanjeevaiah TPS	1,416	2,492	1.59
Rajasthan	Suratgarh TPS	1,290	2,303	1.47
Delhi	Badarpur TPS	1,237	2,202	1.41
Uttar Pradesh	Dadri (NCTPP)	1,221	2,202	1.41
Karnataka	Raichur TPS	982	1,816	1.16
Maharashtra	Dhariwal TPP	846	1,575	1.01
Madhya Pradesh	Bina TPS	689	1,343	0.86
West Bengal	Haldia TPP	519	1,179	0.75
Chhattisgarh	Bhilai TPS	435	1,013	0.65
Bihar	Barauni TPS	290	765	0.49
Jharkhand	Maithon RB TPP	167	470	0.30
Odisha	Sterlite TPP	149	431	0.28
Telangana	Kothagudem TPS	50	207	0.13

Note: Brookings India analysis. This illustrative exercise shows state-wise implication of railways transportation charges on electricity generation cost. Some of these plants use multiple or even varying sources of coal.

Appendix 3: Changes in IR's freight rates in the past five years

In the past few years IR has made several changes in the freight rates of various commodities, especially for carrying coal whose rates revision is more than other commodities; both have risen faster than wholesale inflation (Figure 13).[25] Table 19 shows FY 2012 onwards the frequency of freight rates revision along with the number of slabs in the chosen distance buckets.

Figure 13: YoY per cent change in IR's coal freight rates vs. WPI



The shaded part of the Table 19 shows the changes in freight rates only for coal. The high frequency of changes in coal freight rates has a negative implication for the stability of cost of electricity generation by thermal power plants, even if in theory they are allowed to pass these through to consumers. The regulatory process may allow it, but it takes time and happens well after the fact, impacting cash flow requirements.

Not only the frequency of change in freight rates but also the increase in the per tonne cost of delivered coal affects PLFs of distant power plants due to the merit order based electricity procurement by the DisComs. The annual graphs (Figure 14) show the million tonnes coal traffic to power plants and corresponding indicative revenue[26] in at various

[25] The freight rates are taken for a distance of 611km for all the years to calculate the rate of freight increase and it includes the applicable busy season surcharge and development charge for the respective years. The WPI data is from the Office of Economic Advisor, GoI.

[26] These numbers do not represent the actual revenue but are just indicative numbers calculated based on the tonnes of coal carried in a particular distance slab and the weighted average per tonne freight rate in that particular slab. The calculated weighted average freight rate includes coal terminal charge (applicable only in FY 2017) and does not include the busy season surcharge and development charge.

distance slabs. It is evident from these graphs that IR is continuously losing its coal revenue share from long lead coal traffic. In response to the falling revenue from coal at longer lead distance, IR has increased the net freight rates per tonne for coal. Perhaps in response, the most recent distance slab rationalisation for coal has effectively increased per tonne rates for coal within 700 km and reduced per tonne rates beyond 1,500 km.

Figure 14: Million tonnes coal traffic to power plants and corresponding indicative revenue at various distance slabs

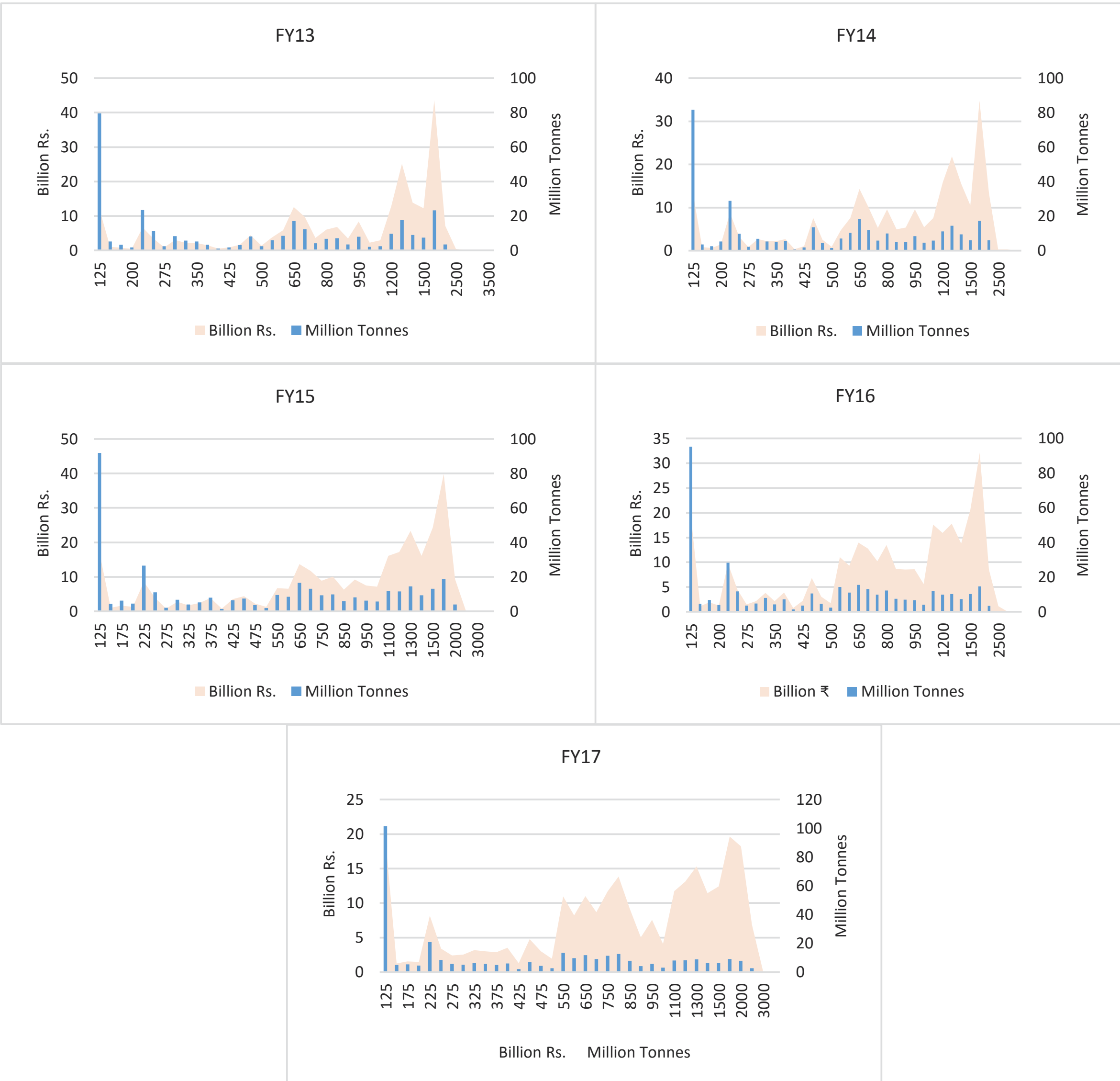


Table 19: Frequency of freight rates revision along with the number of slabs in the chosen distance buckets (FY 2012 onwards)

Financial Year	Frequency	From	To	Duration (Days)	Number of slabs between distance buckets								Total slabs	Comments
					1-100	101-200	201-500	501-1000	1001-1500	1501-2000	2001-3000	3000-3500		
FY12	2	1-Apr-11	5-Mar-12	339	1	10	30	38	20	20	40	20	179	All commodities, slab change & rate change
FY12		6-Mar-12	31-Mar-12	390	1	4	12	10	5	2	2	1	37	All commodities, rate change
FY13	1	1-Apr-12	31-Mar-13		1	4	12	10	5	2	2	1	37	"
FY14	2	1-Apr-13	9-Oct-13	191	1	4	12	10	5	2	2	1	37	"
FY14		10-Oct-13	31-Mar-14	257	1	4	12	10	5	2	2	1	37	"
FY15	2	1-Apr-14	24-Jun-14		1	4	12	10	5	2	2	1	37	"
FY15		25-Jun-14	31-Mar-15	279	0	4	12	10	5	2	4	2	39	"
FY16	1	1-Apr-15	31-Mar-16	510	0	4	12	10	5	2	4	2	39	"
FY17	2	1-Apr-16	23-Aug-16		0	4	12	10	5	2	4	2	39	"
FY17		24-Aug-16	31-Mar-17	319	1	4	4	12	25	50	100	50	246	Only coal, slab and rate change
FY18	5	1-Apr-17	9-Jul-17		1	4	4	12	25	50	100	50	246	
FY18		10-Jul-17	25-Jul-17	15	1	4	4	12	25	50	100	50	246	Only coal rate change
FY18		26-Jul-17	30-Sep-17	66	1	4	4	12	25	50	100	50	246	"
FY18		1-Oct-17	14-Jan-18	105	1	4	4	12	25	50	100	50	246	"
FY18		15-Jan-18	till date		1	4	4	12	25	50	100	50	246	"

Source: IR freight circulars

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