Operational policies based on fare-box revenue management of the Indian railways

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Abstract: Indian railways (IR) is one of the oldest and single largest public transportation organisations in the world. Many of the routes and services are not profitable, but IR, being a state operator is obliged to operate them for political and social obligations. We developed a framework to compute the operational cost per trip of an IR passenger service using actual data. The total operational cost was evaluated against generated revenue, and it was found that break even could not always be attained. The proposed framework mandates significant changes in IR thought process and operational policy decisions, but it is pragmatic, viable and does not compromise customer benefits, we believe. We present the framework; illustrate the same using real data from few premium services and our detailed analysis.

Keywords: total cost of operations; profitability of trains; operating costs; fare-box revenues.

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1 Introduction

Profitability in public transportation services is generally evaluated against a baseline of variable costs of operations that include costs related to fuel, maintenance, cleaning, catering, etc. However, it is not uncommon to consider apportioned values of fixed cost components such as employees’ salaries, infrastructure costs in evaluating operational profit from an accounting perspective. Typically, private transportation service providers (European rail operators/airlines) differentiate operational profitability based on variable costs from apportioned values of fixed costs (Merkert et al., 2010). Thereby, organisations clearly understand their money flows and are able to better control and manage their costs and profits. Unfortunately, such evaluation of operational profit is quite challenging in railway transportation services, such as in South East Asian countries, where infrastructure, rolling stock and systems are all owned, operated and managed by the state. For example, IR owns a rail network of 67,368 KMs. (Y.B. 2016–17), and operates 13,329 passenger services daily catering up to 22.24 million passengers (New Catering Policy, 2017), the ownership, operations, and management are all with the Government. A single train service between an origin-destination pair may traverse through the jurisdiction of multiple local control authorities (called as zones/divisions in IR), and there could be significant variations in the operational costs incurred for the same item at different zones. Nevertheless, computing operational cost is pertinent for managing expenses and maximising profits. We present the list of fully distributed costs [excluding acquisition costs (AC), infrastructure costs and salaries) incurred by few premium IR services (Rajdhani, Humsafar, Shatabdi and Duronto express) in Table 1 from the Interim report published by the Ministry of Railways in 2015 (Interim Report of the Committee for Mobilization of Resources for Major Railway Projects and Restructuring of Railway Ministry and Railway Board, 2015). We have limited our scope towards driving operational profits notwithstanding other fixed costs and salaries.

Table 1 Fully distributed costs for Rajdhani, Shatabdi, and Duronto (2014–2015)

Train no.	*Itinerary*	*Coaches*	*Distance (km)*	*Revenue/trip (Rs)*	*Cost/trip (Rs)*	*Profit/loss per trip (Rs)*
			Rajdhani Express			
12235	DBRG-NDLS	20	2,453	3,046,580	4,494,832	(1,448,252)
12301	HWH-NDLS	20	1,447	2,118,708	2,049,608	69,100
12309	NDLS-RJPB	21	1,001	1,759,609	1,501,893	257,716
12313	SDAH-NDLS	20	1,454	2,121,310	2,056,328	64,982
12424	NDLS-DBRT	19	2,438	3,194,791	3,829,002	(634,211)
12952	NDLS-BCT	20	1,384	2,206,010	1,891,494	314,516
			Shatabdi Express			
12001	NDLS-HBJ	17	707	1,182,530	932,536	249,994
12006	KLK-NDLS	14	303	515,676	444,148	71,528
12011	NDLS-KLK	17	303	675,531	518,983	156,548
12015	NDLS-AII	15	443	634,634	700,621	(65,987)
12029	NDLS-ASR	19	448	874,764	683,615	191,149

Table 1 Fully distributed costs for Rajdhani, Shatabdi, and Duronto (2014–2015) (continued)

Train no.	*Itinerary*	*Coaches*	*Distance (km)*	*Revenue/trip (Rs)*	*Cost/trip (Rs)*	*Profit/loss per trip (Rs)*
			Duronto Express			
12213	YPR-DEE	16	2,367	2,082,170	2,551,347	(469,177)
12246	YPR-HWH	16	1,946	1,589,578	1,731,113	(141,535)
12223	LTT-ERS	14	1,599	1,036,742	2,127,222	(1,090,480)
12261	CSTM-HWH	18	1,969	2,144,657	2,353,701	(209,044)
12263	PUNE-NZM	17	1,520	1,757,203	1,790,407	(33,204)

We observe that there are few services (12235, 12424, 12015, 12213, 12246, 12223, 12261, 12263) belonging to premium category trains that incur an operational loss. We propose addressing these loss-making services; we develop a few operational directives to turn around the financial implications of such services on IR.

In this paper, we develop a framework to compute the operational costs and illustrate the framework using actual data from three IR services in detail. We also study the correlation between train occupancy factors and the profits generated. Our studies led us to some very interesting observations and useful insights for railway operators, who are keen to control their costs.

The rest of the paper is organised as follows: We discuss relevant literature on cost based analysis on public transportation services in Section 2. The framework that we have developed to evaluate the cost of operations in IR is presented in Section 3. A brief Section 4 follows to discuss the computation of operating profits. In Section 5, we use actual data from the IR (Train no. 12957 – Swarna Jayanti Rajdhani express, 12571 – Humsafar express, 12035 – Jaipur-Agra Fort Shatabdi Express and 12213 Yesvantpur-Delhi Sarai Rohilla Duronto Express) to illustrate our proposed framework. We present a critical discussion on the IR dynamic fare mechanism in Section 6. A contextual discussion of relevant IR policies is presented in Section 7. We present the managerial inferences in Section 8, followed by concluding remarks in Section 8. Details of catering charges, crew running allowance, and load factor of few train services are provided in Appendix.

2 Literature review

In research literature on economics of public transportation services, airline pricing is well discussed. A recent work by Bogaard and Lijesen (2019) apply regression analysis to understand fare-to-fare elasticities of adjacent flights operated by different airline operators. They infer that demand volatility would affect price dispersion only at the route level; which means if there are multiple services that cater to a specific demand (a particular route at a particular time), differential pricing may not be an appropriate approach to maximise profits. There is a strong correlation between transport policies and economic benefits. Njoya (2019) proposes that price modification is an effective approach to enhance a transport service provider's connectivity and competitiveness, based on the context of Egyptian air transportation services. Typically, most of the research literature on transportation services are concerned about optimal pricing for profit maximisation and in this paper, we propose a cost optimisation for profit maximisation.

In this section, we discuss a comprehensive set of literature on cost computation in rail transport services and operational profits in rail transportation.

Specifically, railway transportation is a high capital-intensive industry that is mainly operated for public welfare and social good (Blanchard and Fabrycky, 1990). It is nearly impossible to recover the full cost of running the transport services from the fare box revenue alone if fixed costs related to infrastructure, rolling stock, maintenance, and upgradation are considered (Ferry and Flanagan, 1991). A paper by McCarthy and Zhai (2019) suggest that the overall revenue of a railroad operator is generated by short lines, by empirical analysis of the Georgia Department of Transportation services. Another work by Canıtez et al. (2019) studies the commercial aspects of Istanbul's public bus operators and they develop a nonlinear mathematical programming model to evaluate the optimal contractual payments. Revenue management in the Indonesian passenger rail transport services has been modelled and analysed by Pratikto (2019). Several state-operated transportation organisations provide multiple concessional fares to different segments of the society as a social commitment and public good. IR subsidises nearly 43% of the total ridership, and that makes recovery of operational cost from fare-box revenues more difficult.

A railway costing model has been developed by CPCS Transcom Limited, through the World Bank funding, to facilitate railway companies understand the operating cost of doing business. The model is termed as Operational Simplified Costing Analysis for Railways (OSCAR) and is currently used by more than 20 companies in Africa and Asia to estimate their operational costs and to optimise the tariffs by computing the movement of passengers and freight from point A to point B. The following cost components are considered in the OSCAR model:

- Direct variable cost: Costs based on resources that are required to operate a service such as fuel, crew, yard and terminal cost, rolling stock and infrastructure maintenance.
- Variable operating cost: Includes the direct variable cost above plus depreciation cost of the transported commodity (either freight or passengers).
- Total long-term variable costs: Includes the variable operating cost above plus capital cost or one-time investments.
- Total costs: Includes the long-term variable cost plus fixed cost, which is one-time expense.

The output from this model helps companies in better tariff fixation (based on costs) and to help them better evaluate subsidies and concessional fares.

A directive of the European Union 2012/34/EU (21 November 2012) mentioned that "the charges for … [rail] infrastructure … shall be set at the cost that is directly incurred as a result of operating the train service" (from now on – direct costs). According to the Directive's delegation, the European Commission (hereinafter – EC) provided common regulation 2015/909 on the modalities for calculation of cost that is directly incurred as a result of operating the train services; following which many scientific studies were conducted on EU passenger transportation. Benchmarking business performance of Container Corporation of India (CONCOR), a subsidiary of IR was done using data envelope analysis (Bhanot and Singh, 2014). However, neither IR nor any independent organisations have conducted scientific analysis on activity-based costing for passenger/freight train operations of the IR. Therefore, in practice, decisions related IR operations have not been economically justified so far.

Life cycle cost (LCC) and the total cost of ownership (TCO) are two crucial financial measures that are used for decision making in acquisitions to evaluate the value of any capital equipment (Hampton, 2004; Humphries, 2004). LCC refers to all costs associated with the product or system development; this includes costs incurred in conducting requirement analysis, design, production, operation, and maintenance and also disposal of products and systems. The TCO is a philosophy, which is aimed at understanding the actual cost of buying a particular product or service from a specific supplier (Kumar et al., 2000). In countries where the private players are allowed to operate their trains, these activities are contracted/outsourced or done in-house, but in case of IR, design, production, maintenance, and operations of a particular train are carried out by corporations wholly owned by the Ministry of Railways. The two measures are critical to the decision-making, and budget planning activities carried out throughout the useful life of any equipment.

Computation of LCC/TCO support (Kumar et al., 2004) the following:

- effective evaluation of investment options
- impact study of all costs including the initial capital costs
- effective management of completed and operational projects
- choosing between competing alternatives.

IR being a state operator, often compromises some of the above commercial factors to fulfil its social obligations. Manville (2018) infers that revenue should be strictly considered along with socio-political considerations in proposing transport policies if conflicts are to be mitigated. Typically, transport planners and policymakers decide based on the economic rate of return and its multiplier effects, rather than financial rate of return.

The LCC focuses on several phases in a life-cycle. Some are listed below.

1 requirements (functional specification)
2 concept/feasibility studies
3 design and development
4 production
5 testing and certification
6 operation, maintenance and support
7 disposal.

Whereas, TCO focuses on identifying all future costs and discounting them using a discount rate depending on the riskiness of the asset. Following are the elements of cost of ownership (Woodward, 1997):

- Initial capital costs: Includes procurement, commissioning and financing equipment, rakes, locomotives and other mandatory spare parts.
- Life of the asset: While different determinants of an asset's life expectancy are discussed in Ferry and Flanagan (1991), our focus is restricted to the functional life, which is the time-period over which the need for the equipment is anticipated.
- Discount rate: It should be deduced after comparing the riskiness of similar equipment. High discount rate tends to favour options with low capital cost, short life, and high recurring cost, while a low discount rate has an opposite effect.
- Operating and maintenance costs: In case of rakes and locomotives, a significant portion of TCO comes from repair and maintenance costs viz. spare parts, wheelsets etc. while operating costs involve fuel for locomotives.
- Disposal cost: Cost incurred by the owner in disposing and scrapping of an asset once its functional life is exhausted.

All the above factors are critical in evaluating LCC and TCO; however, both LCC and TCO are subject to uncertainties and assumptions. These assumptions are to be vetted before calculating the costs because one wrong assumption can make or break the deal. To address this aspect and facilitate a better understanding of uncertainties involved in cost components, the major sources of uncertainty are laid out in Macedo et al. (1978) as:

- Differences between the actual and desired performance of the asset could affect future operation and maintenance cost.
- Modifications in user activity can lead to changes in operational assumptions.
- Technology advancements and the possibility of future deployment are likely to generate other lower cost alternatives, make current systems obsolete and hence shorten the economic life of an asset.
- Macroeconomic factors viz. change in manpower, fuel prices, inflation can affect future alteration costs.

To address the sources of uncertainty in LCC and TCO that usually result from the inadequacy of input data, according to Blanchard and Fabrycky (1990), the following are subject to sensitivity analysis:

1 frequency of the maintenance factor
2 variation of the asset's utilisation or operating time
3 extent of the system's self-diagnostic capability
4 variation of corrective maintenance hours per operating hour
5 product demand rate
6 ridership rate
7 the discount rates.

Turnaround of the Indian railways without any involvement of private enterprises is discussed in Gupta and Sathye (2010). However, the authors do mention about two major (technical and financial) risks of the turnaround. The policy approach that we propose in this paper is focused primarily on improving operational efficiency, thereby reducing operational costs directly and contributing to organisational profit, indirectly. Apart from that, IR has proven records for improving organisational productivity without the support of private establishments (Bogart and Chaudhary, 2015).

Existing literature covers methodologies of calculating operational costs (Blanchard and Fabrycky, 1990) in various countries, challenges faced in implementing them and approaches to overcome those inefficiencies. In the context of IR, no such formal studies have been conducted. If only IR operations were unbundled and privatised, the operational cost of running every single service could be possibly estimated, but it is not so. Unless the individual cost components are understood and evaluated, measuring revenues and profitability are near impossible.

In this paper, we propose a framework to evaluate TCO and LCC of IR by attempting to break down the various cost components. The framework is illustrated through few specific data from IR premium services:

1 Ahmedabad-New Delhi Swarna Jayanti Rajdhani Express
2 Gorakhpur-Anand Vihar Terminal Humsafar Express
3 Jaipur-Agra Fort Shatabdi Express
4 Yesvantpur-Delhi Sarai Rohilla Duronto Express.

For an inquisitive reader, our findings are interesting and insightful; based on which, we also present our recommendations to the IR. Some of our recommendations challenge the fundamental operations management policies of the Indian railway, as our findings demonstrate that simple managerial corrections to specific existing operational guidelines can cut down the operational expenses in a significant manner, without any compromise on the social obligations that IR is mandated to.

3 A framework to evaluate total cost of operations in IR

TCO is influenced by many factors, viz., reliability, maintenance and inter-operability (Hudenko et al., 2016). The TCO decreases as the reliability increases. Similarly, better maintenance and interoperability decreases the maintenance and support cost and hence decreases the TCO. However, increasing reliability, maintenance and interoperability requires additional resources during the design and product development stage and hence it is likely to increase the initial procurement cost. In this section, we present a framework for computing TCO under the assumption that acquisition, operations, and maintenance activities are carried out by a single entity so that variations in purchasing costs of multiple numbers of the same items are eliminated. However, some of the IR purchases do not happen so; empowerment for financial decisions is likely to vary across various zones/divisions/sections. Therefore, the same equipment or commodity may be purchased at different prices, but commonly used by the IR.

3.1 Acquisition costs

In IR, upgradation of locomotives, infrastructure and rakes are planned centrally at the Ministry of Railways through the Railway Board. Procurement and upgradation decisions are made on past trends, sectoral analysis, the rate of growth, traffic targets and analysis of wear and tear. Funding for procurement and upgradation of infrastructure and rolling stock is generally met from gross budgetary support, internal generation and extra-budgetary resources (private participation or bonds). Expenditure on the procurement of wagons for incremental traffic is charged to capital funds, and that on replacement account is met out of the depreciation reserve fund. The decision on mode of procurement/manufacturing is generally taken at the central level. This can be done using three modes:

- manufacturing through own production units
- procurement through public/private players
- acquisition through outsourcing via participation of private parties under different schemes, where the railway body will pay yearly rental to the private players.

Once, the mode of acquisition is finalised, the demand requirements are shared with the shortlisted supplier, and the AC are finalised based on coach or locomotive variants, features, interiors, amenities, functional life, maximum permissible speed, etc.

3.2 Catering costs (CTC)

In most premium railway services, on-board catering is made available through a pantry car or other means. The CTC incurred by railways are included in the ticket fare under a separate head called ‘catering charges’. Recently, IR has provisioned its commuters a choice to opt out of on-board catering, and consequently, the catering charges are not being levied in their total fare (New Catering Policy, 2017). IR decides the menu and fixes the tariff of standard meals and A-la-carte items. During a typical journey between two stations, the passengers are provided with food items depending on the time of travel viz. from 7:30 AM to 9:30 AM breakfast is served, from 11:30 AM to 1:30 PM lunch is served, from 5:30 PM to 6:30 AM evening tea and snacks are served and post 8:00 PM dinner is served. The below-mentioned items list down the itinerary:

- morning tea and water bottle
- breakfast
- lunch
- evening tea and snacks
- soup
- dinner
- dessert.

The catering unit charges only the cost price of the food items mentioned above in the total fare. Per se, the catering unit does not earn any profits by catering, but this initiative generates goodwill among the passengers and also there is a small revenue component associated with volume discounts which the catering units avail from the secondary vendors. The catering attendants are either hired by the catering authority or outsourced to a contractor, and they are paid monthly salaries. In Appendix, Tables A2 and A3 list out the applicable catering charges in 1-AC and (2-AC and 3-AC), respectively. Table A4 lists the tariff in static and mobile eateries on the railway platforms.

3.3 Linen management costs (LMC)

IR also provides a bed-roll kit to their passenger that includes bed-sheets (cotton/khadi), pillow with a cover, face towel, and a blanket. In higher classes, coaches are fitted with bathrooms, and passengers are provided a bath towel. In some zones of the IR, all the activities are bundled, and the linen management tender entails procurement, washing, and distribution of bed-roll kits to the passengers while in others, the activities are unbundled and given to different contractor/agencies. The quantity, quality, and specifications of bed-roll kit items are specified by IR. For any loss or pilferage contractor is liable to pay the penalty. IR also conducts independent audits to keep a check on the linen contractor. The linen management also includes cleaning of items in a bed-roll kit- the bed sheets, pillow cover, bath-towel and face-towel are to be washed after every trip while the blankets are to be cleaned once in a month in a mechanised laundry. The laundry charges are also fixed upfront and are subject to change after every renewal of contracts. The costs are not explicitly charged in premium trains; however, in superfast trains where the linen service is not mandatory, the bed-roll kit is given at nominal charges (which can cover the laundry and distribution costs).

3.4 Coach attendants costs (ACCA)

Each coach in a premium train carries one or two escorting coach attendants, and their role is to provide linen, maintain the temperature, and report any incident to the running staff. These activities are generally contracted out using a tender process to a private party, and the contractors are paid on an hourly basis (at a rate decided in the contract). The contractors, in turn, pay the attendants a monthly salary based on his experience, running time and grade.

3.5 Electrical staff costs (ESC)

While for minor faults and electrical failures, coach attendants are equipped and trained for repair and maintenance; serious errors come in the ambit of electrical staff that travels as part of the crew in a train. The number of electricians and supervisors are specified in the contract and varies from train to train and zone to zone. These activities are also outsourced to the private contractors who are paid on hourly or trip basis.

3.6 Cleaning costs (CLC)

After every trip the coaches get dirty, and they are cleaned periodically or by on-board housekeeping staff. In IR, cleaning of coaches involves five types of maintenance activities

a primary – to run with Round Trip Break Power Certificate (RBPC) up to 3,500 Kms–6 hrs (on pit from line block to line release)

b secondary – 5 hrs (on pit from line block to line release)

c for watering and cleaning at another end – 3 hrs the rake placed in washing siding

d for watering and cleaning on the platform – 2 hrs

e for platform return trains 2 hrs are ensured for dry sweeping, cleaning of toilets and watering.

Apart from cleaning mentioned above, on-board housekeeping staff (OBHS) system ensures that coaches and toilets are cleaned, as and when required.

3.7 Running staff costs (RSC)

Apart from their basic pay, dearness allowance, HRA and travel allowance, the running staff is entitled to running allowance or mileage allowance which is given to the loco pilots and guards based on the number of kilometrrs they travel. The mileage allowance is fixed by the railway board and is regularly revised from time-to-time. Loco pilot, assistant loco pilot, and guard are entitled to a running allowance. These costs can be directly attributed to operational costs of running a train. Apart from running allowance, railway staff is paid traveling allowance depending on their grade.

In Appendix, Tables A5 and A6 list out the running costs of pilots and guards, respectively.

3.8 Locomotive fuel costs (LFC)

Heavy railway systems usually deploy two kinds of locomotives – diesel and electric. The mileage depends on the load and is generally calculated in litres/GTKM in railways and not litres/km. Energy consumption details are given below.

Diesel

- for Alco (4 stroke diesel engine – 3,300 ghp), Idle = 22 litres/hr and 8th notch top speed = 540 litres/hr (RDSO, Ministry of Indian Railways)
- for EMD locomotives (2 stroke diesel – 4,500 ghp), Idle = 11 litres/hr and 8th notch top speed = 600 litres/hr (RDSO, Ministry of Indian Railways)
- for a train with 24 coaches, fuel consumption varies from 4 litres/km to 7 litres/km; considering diesel costs as Rs 62.25/litre, diesel costs would be Rs 244 to Rs 427/km., approximately.
- electric.

Power consumption on AC locos is measured by tonnage/Kms. For a conventional locomotive, it varies from 5–7 kW per tonne per km. For modern 3 phase loco's like WAG-9/H or WAP-7 if regenerative braking is used, then it is less than 5 KW/tonne-km.

3.9 Power car costs (PCC)

Premium trains have both AC and non-AC coaches which require power and this power is provided by end on generator (EOG) cars attached at the extremes in LHB rakes. While in ICF coaches, it is self-generating. The quantity of fuel (high-speed diesel) required in Generator set depends on the load of the train in terms of KwH which in turn depends on the composition of coaches, number of coaches and season.

Given a brief and succinct description of various cost components involved in a train operation, the TCC is formulated as:

$$\begin{aligned}\text{Total operating cost / trip (TOC)} = \text{LMC} + \text{ACCA} + \text{ESC} + \text{CLC} \\ + \text{RSC} + \text{LFC} + \text{PCC},\end{aligned} \tag{1}$$

where

- LMC is the linen management costs
- ACCA is the coach attendant costs
- ESC is the electrical staff costs
- CLC is the cleaning costs
- RSC is the running staff costs
- LFC is the locomotive fuel costs
- PCC is the power car costs.

To make an effective assessment, all the above costs are to be deduced for every trip of train service.

3.10 Revenues

Railways mostly earn from three kinds of revenues in operation of trains – advertisement revenues, entertainment revenues and fare-box revenues.

- *Advertisement revenues (AR)* – This involves both internal and external advertisements and also through the vinyl wrapping of train exterior (including windows of AC coaches)
- *Entertainment revenues (ER)* – It focuses on monetisation of entertainment based services on trains through audio (PA systems) and video systems (personal devices of the passengers). The content includes movies, shows, and educational programs in both paid and unpaid formats.
- *Fare-box revenues (FR)* – Fare-box revenues are generated from passenger and freight services. It includes payments for rides (passenger) / transportation charges (per tonnage weight for freight), including cash, fare-cards, tickets, tokens, and passes.

4 Calculating the operating profits

$$\text{Gross profit} = \text{Total revenue} - \text{Operating expenses (costs)} \quad (2)$$

$$\text{Gross profit ratio} = \frac{\text{Gross profit}}{\text{Net revenue}} \times 100 \quad (3)$$

A high gross profit ratio indicates a good recovery of operational expenses as it implies that:

1 the operating costs of a train are relatively low

2 increase in revenue is mainly from fare-box sources when operating costs remain constant

3 operating costs decline, when revenue remains the same.

On the contrary, a low gross profit ratio implies that:

1 profit is relatively small

2 operating cost is relatively high (inefficient utilisation of rakes and locomotives, uncontrolled expenditure on cleaning and maintenance activities and so on); (iii)

3 low revenue income (due to lost sales to competing transport modes, inferior quality of services, lack of demand and so on).

Currently, IR operates every service, even if the operational cost is not recovered. Similarly, if the demand is more than the capacity, dynamic fares are invoked; which sometimes encourages a balking customer to move to airline service. Our proposed framework for IR challenges both the above situations.

5 Illustration of the framework using real data from IR[1]

Indian railways operates some premium class of services and of which we consider one particular train in each category of service, namely:

1 12957 Swarna Jayanti Rajdhani Express

2 12571 Humsafar Express

3 12035 Jaipur-Agra fort Shatabdi Express

4 12213 Yesvantpur-Delhi Duronto Express.

In Table 2, we present the computed value of the total operational costs and the incremental cost per coach of each of these trains from the actual data. The incremental coach cost is approximated, specifically in the case of Shatabdi express (as few cost parameters may not be relevant), to maintain consistency. In Table 3, we present the total earnings, gross profit and gross profit ratio for each of these trains at various occupancy levels and also tatkal[2] reservation scheme. IR Revenues from tatkal bookings were known; but, data related to tatkal for useful interpretations on the breakeven of the operational expenses were not available.

Comparing the total operational costs and revenues for the corresponding trains from Tables 2 and 3, we attempt to deduce the percentage of occupancy at which breakeven of actual expenses happen. We find the breakeven occupancy values are 28%, 36%, 21% and 46%, respectively, for (12957) Ahmedabad-New Delhi Rajdhani, (12571) Gorakhpur-Anand Vihar Humsafar express, (12035) Jaipur-Agra Fort Shatabdi express and (12213) Yeshvantpur-Delhi Duronto express.

Table 2 Operational costs for Rajdhani, Humsafar, Shatabdi, and Duronto (2017–2018)

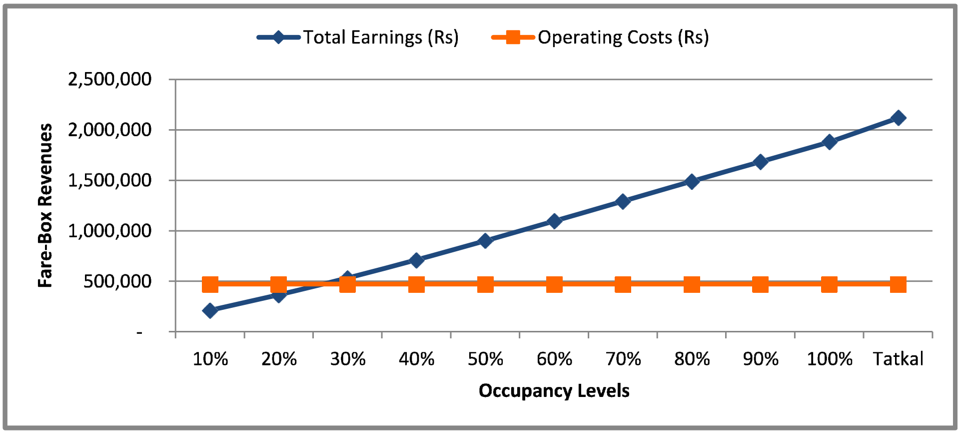
Cost heads	*12957 Ahmedabad-New Delhi Rajdhani*	*12571 Gorakhpur-Anand Vihar Humsafar*	*12035 Jaipur-Agra Fort Shatabdi*	*12213 Yeshvantpur-Delhi Duronto*
Linen cleaning costs	27,384	27,099	-	66,825
Coach attendant costs	11,513	12,649	2,205	20,295
Electrical staff costs	2,567	2,567	1,848	5,134
Cleaning costs	9,270	6,478	1,977	51,800
Running staff costs	6,934	5,600	1,778	17,636
Locomotive fuel costs	227,682	236,839	24,315	523,327
Power car costs	186,750	186,750	18,765	373,500
Total operational costs	472,100	477,982	50,888	1,058,517
Incremental cost/coach	23,868	23,868	23,868	23,868

Note: A more detailed computation of each train service is provided as a supplement.

Source: Authors, Indiarailinfo, Indian Railways and RTIs

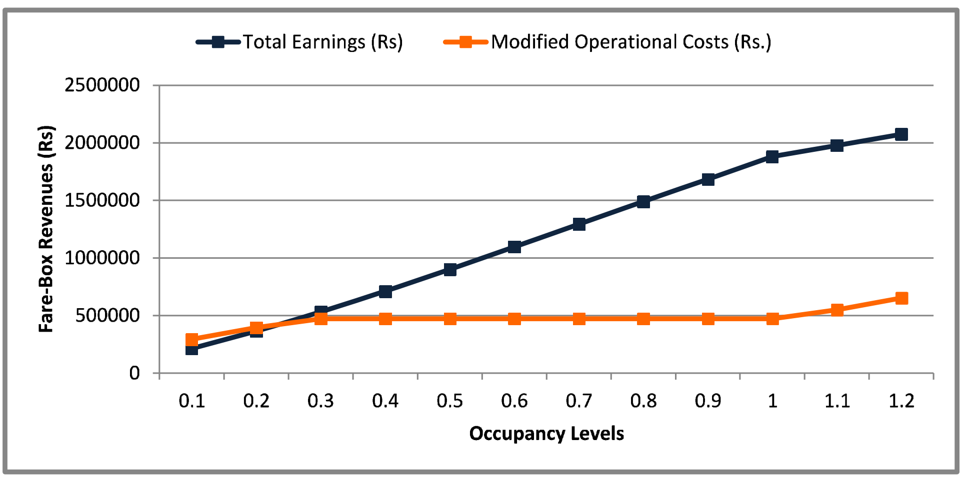
We propose that whenever, occupancy levels are less than breakeven and do not justify recovery of the operational expenses, few carriages may be removed from the rake link. Similarly, when there is huge demand which is more than the available capacity of the rake link, IR may also consider adding few more carriages so that higher revenue can be realised. This proposal conflicts with the current IR operational practice of rake sharing. We briefly discuss about rake sharing and how rake sharing can be managed in the context of our proposal, in Section 8, titled, managerial inferences. We illustrate the proposal using the specific case of (12,957) Ahmedabad-New Delhi Swarna Jayanthi Rajdhani express in Figures 1 and 2. By such an operational intervention, the operating costs are recovered without compromising on the social values, when the ridership demand is much less than the breakeven level of occupancy and higher profits can be realised with an opportunity to service better, when the ridership demand is higher than the available capacity. Interestingly, Asplund and Pyddoke (2019) recommend that welfare gains for a transport operator would be quite high by reducing the frequency of services in sparse demand areas based on the analysis of city bus services of Uppsala in Sweden. Additionally, running additional services during high demands in IR has been modelled by Kumar et al. (2018).

Figure 1 Total earnings and operating costs of 12957 Swarna Jayanti Rajdhani Express (see online version for colours)



Source: Authors

Figure 2 Total earnings and modified operating costs of 12957 Swarna Jayanti Rajdhani Express (see online version for colours)



Source: Authors

Table 3 Gross profit ratio for four different premium categories of trains (see online version for colours)

Occupancy	*10%*	*20%*	*30%*	*40%*	*50%*	*60%*	*70%*	*80%*	*90%*	*100%*	*Tatkal*
12957 Swarna Jayanti Rajdhani (operating cost = 472,101)											
Total earnings	212,417	365,349	531,186	709,816	901,397	1,097,089	1,292,780	1,488,472	1,684,164	1,879,855	2,117,314
Gross profit	(259,685)	(106,752)	59,085	237,715	429,296	624,988	820,679	1,016,371	1,212,063	1,407,754	1,645,213
Gross profit ratio	(1.22)	(0.29)	0.11	0.33	0.48	0.57	0.63	0.68	0.72	0.75	0.78
12571 Humsafar Express (operating cost = 477,982)											
Total earnings	128,581	257,161	385,742	514,323	642,903	783,540	935,575	1,099,993	1,275,925	1,463,686	1,669,804
Gross profit	(349,401)	(220,821)	(92,240)	36,341	164,921	305,558	457,593	622,011	797,943	985,704	1,191,822
Gross profit ratio	(2.72)	(0.86)	(0.24)	0.07	0.26	0.39	0.49	0.57	0.63	0.67	0.71
12035 Jaipur-Agra Fort Shatabdi Express (operating cost = 50,888)											
Total earnings	26,929	48,917	70,906	92,894	114,883	138,106	162,564	188,257	215,235	242,213	311,288
Gross profit	(23,960)	(1,971)	20,017	42,006	63,994	87,218	111,676	137,369	164,347	191,325	260,400
Gross profit ratio	(0.89)	(0.04)	0.28	0.45	0.56	0.63	0.69	0.73	0.76	0.79	0.84
12213 Yesvantpur-Delhi Duronto Express (operating cost = 1,058,517)											
Total earnings	224,480	448,959	673,439	897,918	1,122,398	1,357,923	1,604,495	1,862,112	2,130,776	2,410,485	2,871,733
Gross profit	(834,038)	(609,558)	(385,079)	(160,599)	63,881	299,406	545,978	803,595	1,072,259	1,351,968	1,813,216
Gross profit ratio	(3.72)	(1.36)	(0.57)	(0.18)	0.06	0.22	0.34	0.43	0.50	0.56	0.63

Source: Authors, Indiarailinfo, Indian Railways and RTIs

6 Dynamic fare mechanism of IR

It is important to note that all premium trains that are considered in the earlier section incorporate dynamic fare scheme and tatkal quota in addition to the normal base fare. At times, because of dynamic fares, lower class seats are priced more than that of higher class seats in superfast/mail trains. Consequently, the passengers try to avoid these premium trains and opt for other superfast trains plying on the same route with lower fares. We present in table 4, a comparison of normal and dynamic fares of different service classes of two trains (12957 Rajdhani and 12915 Ashram Express) that are operated on the same route. The fare of 2AC in 12915 Ashram Express is nearly 25% lower than the highest fare in 3AC in 12957 Rajdhani Express plying on the same route.

In Table 5, fares of 12553 Vaishali express and 12571 Humsafar express are compared. It is observed that the fare of 2AC in 12553 Vaishali Express is nearly 18% lower than the highest fare in 3AC in 12571 Humsafar Express plying on the same route. Though IR invokes dynamic fares to maximise revenues, such discrepancy does not go well with the Indian commuters. IR does have a social obligation to the Indian citizen, being a monopolistic railway operator of the country, and we believe that should not be compromised. Our framework reinforces the socio-political obligation of IR while providing better revenue management and improved customer centricity.

While adding coaches, IR may adopt the current practice of auto-upgrade, so that all bookings can efficiently be allocated a confirmed berth. Regarding the technical feasibility of additional coaches, it has been observed (Gupta and Sathye, 2010) that stations have enough capacity to handle 24 coaches and at present most of the Rajdhani Express (including Swarna Jayanti Rajdhani Express) and Duronto Express trains operate with 19–20 coaches (including 2 Power Cars). There is enough room to augment the train carrying capacity by 25% depending on requirements (Debroy, 2015).

Table 4 Fare Comparison between 12957 Rajdhani and 12915 Ashram Express

Trains	*12915 Ashram Express*			*12957 Rajdhani Express*		
Fare break-up	*AC 3-tier*	*AC 2-tier*	*AC 1st class*	*AC 3-tier*	*AC 2-tier*	*AC 1st class*
Base fare	1,110	1,614	2,774	1,279	1,841	3,174
Catering charges	-	-	-	195	195	220
Reservation charges	40	50	60	40	50	60
Superfast charges	45	45	75	45	45	75
Taxes 5%	60	85	145	68	97	165
Gross fare	1,255	1,794	3,054	1,627	2,228	3,694
Dynamic fare	-	-	-	538	967	-
Net fare	1,255	1,794	3,054	2,165	3,195	3,694

Source: Indian Railways

Moreover, with the implementation of head on generation (HOG) in premier trains plying on electrified routes, the requirement of power cars can be eliminated (Jyotika Sood, 2015). This would indirectly have a positive implication on train operations as follows:

1 additional room to add two coaches

2 reduction in high-speed diesel cost used in generator sets of power cars.

Table 5 Fare Comparison between 12553 Vaishali and 12571 Humsafar Express

Trains	*12553 Vaishali Express*			*12571 Humsafar Express*
Fare break-up	*AC 3-tier*	*AC 2-tier*	*AC 1st class*	*AC 3-tier*
Base fare	1,000	1,452	2,484	1,185
Catering charges	-	-	-	-
Reservation charges	40	50	60	40
Superfast charges	45	45	75	45
Taxes 5%	54	77	131	64
Gross fare	1,139	1,624	2,750	1,334
Dynamic charges	-	-	-	623
Net fares	1,139	1,624	2,750	1,957

Source: Indian Railways

A dynamic fare mechanism has been recently introduced in IR and in this section we discussed how dynamic fares are invoked in some of the premium services. It is observed that when dynamic fares are operative, a lower class fare in a premium train is much higher than the higher class fare of a train in the same route. A passenger traveling in that segment might be better off with a higher class of service in a non-premium train than traveling in lower class of service in a premium train. Quite often, dynamic fares of IR are higher than low-cost airline fares of the same routes, which is also not a welcome for the discerning IR customer. The purpose of IR introducing such initiatives of dynamic fares was actually to maximise the revenue generating potential; unfortunately, it has impacted the customers much negatively as demonstrated in this section.

7 Contextual analysis of IR operational policies

- The calculation of operating costs is quite complex in IR because of multiple dependencies between several stakeholders such as train operators, network operators and maintenance service contractors of infrastructure and other assets across multiple zones and divisions. Despite all entities being under one jurisdiction of IR, computation of operational costs is very cumbersome.
- The concept of transfer pricing is still not applicable in the current situation in IR in all operations.
- Unlike other public entities, which publish their procurement cost details on a regular basis, IR does not publish the procurement costs of rolling stock. This further complicates the planning process for policymakers and planners as a detailed cost break-up is not available.
- While each railway zone or railway board follows some methodology to calculate the profitability of trains, the methodology is still not known to people at large and the only source to gauge the profitability of a train is right to information (RTI).

- In most of the train services that were used for illustration in this paper, the net profit ratio gains a positive value approximately at an occupancy level of 40%, which is easily attainable even in the off-peak season. However, this calculation for revenues assumes no concession for senior citizens and specially-abled persons. Had that been included, the Net profit ratio would possibly be positive at higher occupancy levels.
- Also, there are many cost heads which cannot be computed in the present context, but going forward these cost heads (if deciphered) will help in understanding the profitability in more explicit terms.
- In the case of premier trains like Rajdhani, Shatabdi and Humsafar running between major stations, the revenues and profitability are on the higher side. However, there are many premier trains like 12436 New Delhi-Dibrugarh Town Rajdhani Express which run into losses because 3AC fares are comparable to flight charges. This is notwithstanding the fact that flight travel time is 2 hours and 30 minutes to reach Delhi from Dibrugarh in North-east India, and the train travel time is 44 hours.

8 Managerial inferences

Following the operational cost computations presented in Section 5, analysis of IR dynamic fare mechanisms in Section 6 and IR operational policy discussion presented in Section 7, our inferences are broadly two-fold:

1 If the occupancy levels are less than the breakeven point of operational costs and revenue generated, IR must consider reducing the number of coaches to reduce the train running cost, so that the revenues are almost on par with the total running cost, and IR does not incur any loss.

2 Similarly, if there is a substantial demand, IR must consider augmenting few coaches to the current rake composition, so that service is not denied for a customer and business is not lost for IR. During any surge (festivals/events) demands, unless essential, IR may not run any special service; but to add few more coaches to the existing rake. In this manner, IR need not deny confirmed berths to a commuter who needs to travel and also does not lose its business opportunity.

Specific inputs on policy level decisions to IR, the monopolistic Indian national rail operator are:

- IR or Railway Board along with its railway zones should develop and adopt a more structured accounting process to calculate costs, fare-box revenues, and profitability.
- The board should also publish the details of profitability of each train (especially premier trains) every quarter to create a competitive atmosphere among zones and promote best practices.
- Currently, few subsidiary services such as linen management and rolling stock cleaning are administered by respective zones, and there seems to be a considerable variation in the linen cleaning and coach cleaning rates in different zones. The difference is attributed to many factors viz., availability of mechanised cleaning equipment, mechanised laundry, the volume of linen handled, number of coaches

handled, etc. The Railway board should attempt to standardise operational practices and also encourage zones to manage operations competitively.

- While proposing a new train service on a specific route, IR as the railway planner must forecast a range of traffic demand, using formal scientific methods, so that:
  1 the forecasted performance and its seasonal, technological and cyclical fluctuations
  2 the proposed set of evaluation parameters is consistent
  3 externalities, including maintenance and repair are ignored in operational cost computations
  4 LCCs of railway infrastructure elements are considered appropriately (Hudenko et al., 2016).

A limitation of the proposed framework is that IR may not be able to share rakes, which is the current practice. *Rake sharing* should be possibly replaced by *rake composing* at the start location of each service by maintaining additional coaches at major stations and junctions. Said that, rake sharing, by itself was introduced as a cost minimisation exercise by IR. Therefore, for the sake of rake sharing, operating a dead run of coaches with no customer demand is counter-intuitive and is poor management.

9 Conclusions

We have developed and illustrated our framework to analyse public transportation with an objective to maximise revenues from a cost accounting and a service operations management perspective using few premium services of IR presented in Table 1. Several other routes / services face heavy losses (as shown in Table 1). Irrespective of whether a service is loss-making or garners a higher demand than the existing capacity, IR is often compelled to operate all services out of social and political obligation.

Our framework pertains to railway transportation, specifically passenger services and fare-box revenues. Neither infrastructure nor huge investments are to adopt our proposed framework. No organisational change or public finances are proposed. What is necessary from IR is:

1 a fundamental change in thought process

2 a significant policy change in operational planning

3 a one-time operational modification (every time, at the start location of each service), either to decrease or increase the number of coaches based on booked tickets.

If IR adopts and extends our proposed model specifically in those routes/services:

1 the losses can be reduced considerably

2 higher revenues may be realised during heavy/surge demands

3 customer values shall not be compromised.

Specific features of our framework are:

1 feasible to implement with no capital investment or organisational changes

2 customer friendliness and compatibility with national interests

3 scalable, cost-effective and has a scope to encourage IR to expand its network to commercially less lucrative regions

4 sustainable with a considerable potential to eliminate waste expenditure and increase revenues.

Usually, the demand-capacity mismatch in public services is managed by various static approaches and one-off solutions; the novelty of our approach lies in the dynamic management of capacity in train carriages, which other public transport modes (such as bus services or airlines or shipways) are incapable of. Railways should leverage its competitive advantage as a unique transport mode, for higher revenue generation.

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Notes

1 Actual values of data from IR have been used; where data is unavailable, approximated values are used and are mentioned as appropriate.

2 Last minute booking at a premium pricing.

Appendix

Table A1 1AC catering charges in Rajdhani Express

Type of service	*Catering charges disbursed to the license (without GST)*	*Amount of GST at 18%*	*Catering charges to be disbursed to the licensee (inclusive of GST at 18%)*	*Catering charges to be included in the ticket fare inclusive of GST at 18%*
Water bottle	12.5	2.25	14.75	15
Evening tea	41	7.38	48.38	50
Dinner (incl. soup and dessert)	129.5	23.31	152.81	155
Morning tea	12.5	2.25	14.75	15

Source: IRCTC

Table A2 2AC and 3AC catering charges in Rajdhani Express

Type of service	*Catering charges disbursed to the license (without GST)*	*Amount of GST at 18%*	*Catering charges to be disbursed to the licensee (inclusive of GST at 18%)*	*Catering charges to be included in the ticket fare inclusive of GST at 18%*
Water bottle	12.5	2.25	14.75	15
Evening tea	40	7.2	47.2	50
Dinner (incl. soup and dessert)	112	20.16	132.16	135
Morning tea	8	1.44	9.44	10

Source: IRCTC

Table A3 Running allowance for loco pilots and assistant loco pilots (per 100 Km)

Category	*Grade pay*	*Rate of RA as per RBE 202/2008 01.09.2008*	*Rate of RA wef 01.01.2011*	*Rate of RA enhanced wef 01.01.2014*
Loco Pilot Mail	4,200	170	212.5	255
Loco Pilot Passenger	4,200	169	211.25	254
Loco Pilot Goods	4,200	168	210	253
Loco Pilot Shunting I	4,200	130	162.5	195
Loco Pilot Shunting II	2,400	126	157.5	189
Sr Assistant Loco Pilot	2,400	126/81(Shg)	157.50/101.25	189/121.50
Assistant Loco Pilot	1,900	121/78(Shg)	151.25/97.50	181.50/117

Table A4 Running allowance for guards (per 100 Km)

Category	*Grade pay*	*Rate of RA as per RBE 202/2008 01.09.2008*	*Rate of RA wef 01.01.2011*	*Rate of RA enhanced wef 01.01.2014*
Mail Guard	4,200	154	192.5	231
Passenger Guard	4,200	153	191.25	229.5
Sr Goods Guard	4,200	152	190	228
Goods Guard	2,800	151	188.75	226.5
Sr Assistant Guard	2,400	90	112.5	135
Assistant Guard	1,900	86	107.5	129

Table A5 Tare weight and loaded weight of LHB coaches

Coach description	*Tare weight (t)*	*Payload (t)*	*Loaded net (t)*
LWLRRM (power car)	60.8	4.2	65
LWACCN (EOG AC 3-Tier)	45.86	5.5	51.36
LWACCW (EOG AC 2-Tier)	44.8	4	48.8
LWFAC (EOG 1st AC)	44.6	2	46.6
LWCBAC (pantry car)	47.9	4	51.9

Source: RDSO