Alternative Approach to Costing on Indian Railways: Linking Outputs and Expenses to Activity Centres

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Abstract

Costing of railway systems is complicated due to a large proportion of sunk and joint costs. Indian Railways (IR) currently estimates costs at the zonal level by first segregating the direct costs, i.e. costs which can be assigned to a service, and joint costs, i.e. costs which are incurred jointly for more than one service. While the direct costs are assigned to the service, the joint costs are assigned based on ratios worked out for assigning costs between various services. Compared to the method in vogue, the paper proposes and demonstrates a disaggregated approach for developing costs. Unlike the current approach, the proposed approach develops expenses and performance measures at the activity centre level, i.e. at division, shed, and workshop level. The disaggregated data is used to build statistical models relating expenditure to outputs. The paper also shows how the approach can help in i) separating variable and fixed costs ii) developing costs as per sectional characteristics, iii) comparing and benchmarking performance of entities and finally iv) how the process can be automated. The paper also shows how the work could be useful for the accounts reforms project of IR and to the Rail Development Authority in fulfilling some of its objectives.

Keywords
Railway costing; Statistical models; Indian Railways

1. Introduction

Indian Railways (IR) is an enterprise owned and operated by the Government of India through the Ministry of Railways. It is one of the world's largest railway networks with a route length of 65,436 km and 7,172 stations. It carries a mix of passenger and goods traffic, and in 2014-15, IR carried 8.4 billion passengers and 1050 million tons of freight (Indian Railways, 2015a). Indian Railways is divided into seventeen zones, which are further sub-divided into sixty eight divisions (Indian Railways, 2017).

Rail transport costs are characterised by high fixed cost of track, rolling stock, and buildings but lower per unit fuel and operating costs. Moreover, many costs are joint costs that have to be allocated between several kinds of products and services to arrive at the total cost of each service or product.

In order to facilitate decision making either for long term decisions like investment on infrastructure or for short term decisions like rail operations and pricing, a system of costing which can segregate fixed and variable elements of train operations would be vital. With this as one of the objectives IR has started the Accounts reform

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Note: The article is based on the personal views of the authors and does not necessarily reflect views of the organisations they work for.

project to develop an activity based unit costs (ABUC) (Debroy and Desai, 2017; ICAI Accounting Research Foundation, n. d.; Indian railways, n. d.).

The current costing procedures on Indian Railways (IR) are based on detailed cataloguing of expenses (Indian Railways, 2015b and 2016). The expenses are worked out into fully distributed costs for each service first by segregating the direct costs and joint costs. While the direct costs are assigned to the service directly, the joint costs are calculated based on ratios worked out for assigning costs between various services (Indian Railways, 2003). The current approach, though pioneering, has a number of limitations and has been highlighted in various reports (See Chapter 5 of RITES, 2009; ICAI Accounting Research Foundation, n. d.). Some of the limitations of the costing process are:

- The unit of analysis is the zonal railway while the basic areas of activities are divisions, sheds and workshops.
- Relies on accounting ratios calculated based on study of limited sections and at infrequent intervals
- It is unable to segregate the variable and fixed costs of operations
- It is difficult to segregate the sectional costs especially to bring in effects of various characteristics of the sections

It is in this context a more rigorous process needs to be developed to address the following issues:

- Replace the current method of arbitrary calculation of accounting ratios to assign joint costs to different services with a robust process
- Deepen the analysis by relating costs to activities at a more decentralised level. Shift the cost analysis from zones to divisions, sheds and workshops.
- Segregate variable and fixed costs for various services
- Use the above approach for arriving at a more disaggregated costing
- Also develop approach to calculate costs based on sectional characteristics and sectional traffic

2. Review of Literature on Railway Costing

Railway costing has been an important subject of study both by academics and practitioners and lot of literature is available on the subject. While a brief and limited review is presented below, interested readers are referred to Winston (1985) and Wilson and Bitzan (2003) for an interpretive survey of the literature on railway costing.

Cost studies were undertaken in two broad directions. One direction of work in railway costing is to model at an aggregate level to draw implications for public policy on industry regulation and control. The models, most often, used aggregate data to build cost functions in evaluating how the rail systems were performing over a period of time. Another set of models looked at disaggregate data to model cost from operational perspective. The disaggregate models facilitate segregating costs for each service as per each expense head and also segregate fixed and variable component of the costs.

However, in spite of extensive work, methods for railway costing are still evolving and no model is established as final standard.

Studies on IR costing by academicians are, however, limited and they are described in detail in Alivelu (2006). One of the first studies, by Healy (1964), was an assessment of changes in fares and freights in comparison to the average costs. Koshal (1970) and Varma (1983, 1988) pioneered the econometric study of railway costing using IR level data in building different cost models. Alivelu (2006, 2007) further developed by building cost functions at the zonal level.

The above studies, however, have analysed data either treating IR as one unit (Healy, 1964; Koshal, 1970 and Varma, 1983) or disaggregated to the zonal level (Alivelu, 2006). Unfortunately, the expenses both at the IR level and at Zonal level get aggregated and the richness of data set gets lost in the process of aggregation. Further, predominant drivers of costs are the divisions, sheds and workshops and an analysis at this level relating inputs to the outputs at these individual units would bring out the output to input relationship better. Further, the studies would not be able to assess the cost of a stream of traffic or incorporate the sectional characteristics. The studies do not address the issue of fixed and marginal costs of different services at a more disaggregate level.

From a practitioner perspective, RITES Ltd. conducted pan Indian studies on traffic flows and costs in 1978 and 1986 (RITES, 1980 and 1988) and as a part of the studies RITES estimated railway costs at the sectional level by collecting data from sample sections. The approach was used to relate the sectional costs to the railway operations and estimate the cost of movement for different sectional types. In 1986, the study was limited to a total of 21 sections - 14 in Broad Gauge and 7 in Metre Gauge, to estimate the costs for the Indian Railways.

RITES study makes an inherent assumption that the sample sections are representative of all sections on Indian Railways. As the sample size was limited and variability on IR is very high, the assumption that costs would represent the complete section becomes difficult to sustain. Further, the final costing was dependent on assigning cost ratios similar to the one under taken by IR.

The methods described above are not able to address the issues of a disaggregated costing and also segregate fixed and variable costs of various operations. The exercises were also undertaken at an aggregated level and would not help us in building disaggregated models relating costs to the respective cost drivers.

3. Data and Methodology

Data and methodology are highly intertwined with no linear linkages. Many a time, especially in academic research, methodology is worked out to try out a new approach to a problem and data is set up to validate or invalidate the approach. If data availability is a problem, then either proxies are set up or an experimental approach is taken.

In many cases, especially for real world problems, it is the other way round. Data availability becomes critical and drives the methodology. It may not be the best solution but given the data limitations the proposed solution may be better than the existing solutions. It helps in giving a practitioner a different perspective or a fair idea and helps in developing insights. Later method is followed in the current approach. Data available is reviewed and best possible methods are established to arrive at the costs.

Costs are broadly divided into two components. First component is the costs related to day to day operations, also called as revenue expenses. The second component is investments made for developing assets, called the capital costs. As the drivers for revenue and capital costs are very distinct we deal with each of these items separately here.

A basic schematic of various steps involved in the costing process is given in Figure 1.

Next section deals with development of revenue costs and section 5 deals with capital costs. In section 6 implications of results for different areas are discussed. Finally, in section 7 relevance of the study to ongoing works is highlighted and how the study can be further extended to change the costing methodology on IR is

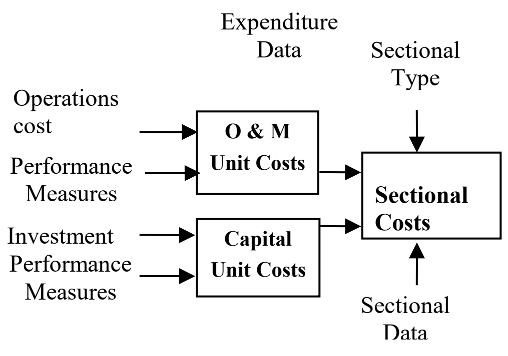

Figure 1: A schematic for a disaggregated cost estimation for Indian Railways

presented.

4. Developing of revenue (operational) cost functions

4.1 Data on revenue expenses and performance measures

The objective is to develop as disaggregate cost functions as possible for the system and an essential prerequisite for this is to have a disaggregate expenditure data. IR developed detailed methodologies for recording expenditure data and the data is highly granular. Expenditure is divided into 15 demands as per the category of expenditure and grouping of these expenditures in common parlance is shown in Table 1.

Table 1: Heads used for classifying expenditure by IR

Sr.No.	Group	Demand No	Demand Name
I.	Policy Formulation and Services Common to all zonal Railways	1	Railway Board
		2	Miscellaneous Expenditure (General)
II.	General Superintendence and Services on Railways	3	General Superintendence and Services on Railways.
III.	Repairs and Maintenance	4	Repairs and Maintenance of Permanent Way and Works.
		5	Repairs and Maintenance of Motive Power.
		6	Repairs and Maintenance of Carriages and Wagons.
		7	Repairs and Maintenance of plant and Equipment
IV.	Operation	8	Operating Expenses-Rolling Stock and Equipment.
		9	Operating Expenses-Traffic.
		10	Operating Expenses-Fuel.
V.	Staff Welfare, Retirement Benefits and Miscellaneous	11	Staff Welfare and Amenities.
		12	Miscellaneous Working Expenses.
		13	Provident Fund, Pension and other Retirement Benefits.
VI.	Railway Funds and payment to General Revenues.	14	Appropriation to Funds.
		15	Dividend to General Revenues, Repayment of loans taken from General Revenues and Amortization of over Capitalisation.

Bulk of the money is spent at the zonal level and these expenses are segregated in demands 3 to 13. The general pattern of expenditure for the year 2006-07 by IR at the zonal level is given in Table **2**. It is seen that single important item of expenditure is fuel and they are followed by other maintenance and operational expenses.

Table 2: Pattern of expenses by IR at the zonal level

Demand	Description	Expenses (in Rs crores)	Percentage
3	General Superintendence and Services on Railways.	1916	5
4	Repairs and Maintenance of Permanent Way and Works.	3358	9.0
5	Repairs and Maintenance of Motive Power.	1835	5
6	Repairs and Maintenance of Carriages and Wagons.	3977	11
7	Repairs and Maintenance of plant and Equipment	1972	6
8	Operating Expenses-Rolling Stock and Equipment.	2790	8
9	Operating Expenses-Traffic.	5754	16
10	Operating Expenses-Fuel.	9733	28
11	Staff Welfare and Amenities.	1542	4

Demand	Description	Expenses (in Rs crores)	Percentage
12	Miscellaneous Working Expenses.	1162	3
13	Provident Fund, Pension and other Retirement Benefits.	1329	4
Total		**35367**	**100**

It may also be noted that classification of expenses is such that many demands have expenditure for different items which should be segregated for cost purposes. For example, demand 5 collates all information on repair and periodic over haul (POH) of both electric and diesel locomotives. Similarly, individual items of interest in costing are spread over many demands. For example, diesel loco haulage expenses are spread over demands 5, 8 and 10. The segregation is possible with further detailing of expenses.

Fortunately, IR maintains expenses in detail in what is called revenue allocation register (RAR). RAR data are kept at the 16 zonal headquarters and, as on 2006-07, data are recorded for 162 accounting units; consisting of 16 zones, 67 divisions and 46 workshops and some miscellaneous accounting units.

Equally comprehensive are the details to which expenditures are recorded. The data on expenditure are hierarchically arranged in order of demand, minor head, sub-head and detailed heads. After compilation of data for all 16 zones, it was observed that data is recorded for 2149 detailed heads.

As the data was compiled for various functioning units – such as divisions, loco sheds and workshops; it is now possible to build the expenditure models relating to those units. Thus instead of analysing at the zonal level, which are 16 in number, the unit of analysis can be extended to 162 accounting units.

Further, each of the expense unit has varying patterns of operations and thus bringing in lot of variability in expenses. For example, expenditure pattern for 7 divisions is plotted in Figure 2 and the Figure shows the high variability in total expenditure and also the way it is distributed across different expense heads.

The variability arises from the underlying characteristics of the divisional operations and their outputs. Of the 7 divisions two Divisions (Bombay Central and Mysore) are predominantly passenger traffic oriented, three divisions (Bilaspur, Dhanbad and Chakradharpur) are mainly freight oriented and the remaining two divisions (Delhi, Secunderabad) have a mix of goods and passengers operations.

Significant variability in inputs (expenditure) and outputs (performance measures) spread over sufficiently large number of units facilitates building statistical models.

Output measures are pooled from different published and primary sources and the list of sources is given in Table 3.

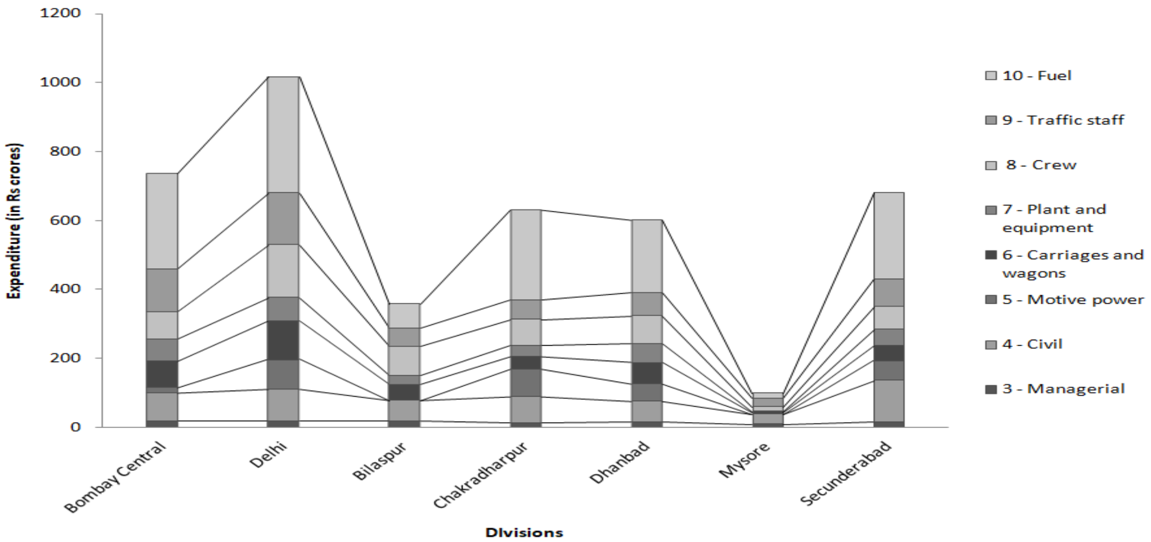

Figure 2: Patterns of expenditure under demands 3-10 on a sample of divisions

Table 3: Sources of data

Railway Board

a) Publications

1) Annual Statistical statements
2) Year Book
3) Annual accounts report
4) Pink book having capital cost
5) Unit cost books for Passenger traffic
6) Unit cost books for Goods traffic

b) Physical Data

1) Shed-wise Diesel loco holding and their service –wise outage
2) Shed-wise Electric loco holding and their service –wise outage
3) Depot-wise Passenger carrying vehicle holding
4) Workshop-wise Diesel Locomotive P.O.H outturn
5) Workshop-wise Electric Locomotive P.O.H outturn
6) State-wise numerical code structure
7) Classification of revenue structure (Abstract-wise & Demand-wise)
8) Detailed classification of demand under minor, sub and detailed heads
9) Commodity-wise Empty return ratio and average lead

ZONAL RAILWAYS

a) Publications

1) G.M, s Annual Narrative Report
2) Division-wise Working Time tables
3) Rake links

b) Physical Data

1) Revenue Allocation Register
2) Zonal Accounting units and primary units
3) Green books (Methodology and apportionment of costs between services)
4) Stations numerical codes
5) No. of stations and block sections
6) Traffic density statements (Traction-wise, Section-wise & service-wise)
7) Sectional capacity utilization
8) Number of bridges & tunnels (important, major & minor) and their track length
9) Average Train load in terms of wagons, Net load and Gross load

RITES

Physical Data

1) Passenger and freight performance data
2) OD flow of passenger and goods traffic

Freight Operating Information Systems (FOIS) operated by Centre for Rail Information Systems (CRIS)

Physical Data

1) Average speed of goods train (Traction-wise)
2) Average load of goods train
3) Rake examination

4.2 Methodology

As discussed in the above sub section that data can be analysed as per requirements at a disaggregate level; it could be at divisional, shed or workshop level.

Similarly, it is also feasible to subdivide expenditure to segregate different streams so that one can estimate elements of costs which would be assigned directly to an activity. Thus from the detailed heads it is possible to segregate civil engineering expenses from signalling expenditure and both of these from expenditures on locomotives and carrying units. Further, expenditure on locomotives could be further sub divided into electrical and diesel. The locomotive expenditure in turn can be further subdivided into day to day operational expense, repair and maintenance (minor repairs) expense and periodic overhaul (major repairs) expenses.

As data at detailed head level is more granular, approach to cost estimation could also be made granular. Based on the data and juxtaposing the basic cost drivers, 15 subcategories of expenses were identified into which the operational costs could be segregated. For each of these 15 sub categories output performance measures and unit of analysis was developed and these are given in Table 4.

Table 4: Expense categories and the performance units

Sl. No.	Elements of costs	Output Measure	Unit of analysis
1	**Diesel Loco**		
a	Repair & Maintenance(R&M)	Number of goods and coaching locos	Loco shed
b	Periodic overhaul (POH_	Outturn of goods and coaching locos	Workshop
c	Fuel Related Operating Expenses	Per 000' GTKMs	Division
d	Operating Exp. other than Fuel	Per 000' GTKMs	Division
2	**Electrical Loco and OHE**		
a	R&M	Per 000' GTKMs	Loco shed
b	POH	Per 000' GTKMs	Workshop
c	Fuel Related Operating Expenses	Per 000' GTKMs	Division
d	Operating Exp. Other than Fuel	Per 000' GTKMs	Division
e	Over Head Equipments	Per 000' GTKMs	Division
3	Permanent Way-Track	Per 000' GTKMs	Division
4	Signal & Telecommunications.	Per Train KM	Division
5	Cost of Other Transportation	Per 000' GTKMs	Division
6	**Cost of Carrying Units**		
a	Wagons	Per Wagon Day	Division
b	Vehicles	Per Vehicle Day	Division
7	Terminal Expenses	Per Tonne	Division
8	Overhead Expenditure	Per Tonne	Division

After the costs are identified linear regression models are set up for each of the expense category relating to the output measures. In this case, the dependent variable comprises the expenditure and the independent variables are the units of output.

4.2.1 Illustration of methodology: A case study of repair and maintenance of diesel locomotives

This methodology is illustrated for repair and maintenance of a diesel locomotive. Diesel locomotives have three kinds of repairs – i) minor attention which is treated as the day to day running repair, ii) repair and maintenance (R & M) under taken in a shed and iii) over haul of a locomotive undertaken in workshops.

Out of the three items above, item (ii), i.e. repair and maintenance, are under taken in a shed and IR has 34 diesel loco sheds spread throughout the country. With shed as unit of analysis, shed expenses become dependent variable and the independent variables are the number of passenger and goods locos maintained in the shed.

Regressing the two we end up with a linear equation:

Y (Repair & Maintenance Expenditure) = 6.5 + 0.23 * Number of passenger locos + 0.186 * number of goods locos (Note: All the estimates are significant at 1% significance level). Adjusted R-squared: 0.7177

The equation can be interpreted that a typical shed would incur a maintenance expenditure having a fixed cost of Rs 6.5 crores per annum and a variable cost of Rs 0.23 crores and Rs 0.186 crores for a goods and coaching locomotive respectively.

4.3 Regression estimates

Similar estimates are made for all the expense components and are given in Table 5.

Table 5: Regression estimates for different expenses

SN	Activity	Adjusted R square value (with p-Value in brackets)	Intercept (with p-Value in brackets)	Variable and associated coefficients (with p-Value in brackets)	
1	Diesel Loco R&M	0.7 (0.000)	6.5 (0.00)	Loco Goods	Mail Link
				0.18 (0.00)	0.22 (0.00)
2	Electric loco R&M	0.47 (0.022)	11.38 (0.07)	Loco Goods	Mail Link
				0.23(0.05)	0.14 (0.01)
3	Diesel POH	0.56 (0.00)	**14.3 (0.36)**	Loco POH	
				0.56 (0.05)	
4	Electric POH	0.45 (0.08)	**13.8 (0.22)**	Loco POH	
				0.27 (0.08)	
5	Coach POH	0.75 (0.000)	**9.4 (0.57)**	**Non AC**	AC
				0.008 (0.75)	0.56 (0.00)
6	Coach R&M	0.750 (0.000)	4.96 (0.10)	Coach Holding	
				0.034 (0.0)	
7	Wagon R&M	0.57 (0.000)	6.5 (0.00)	Total Outrun	
				0.02 (0.00)	
8	Other Transportation	0.51 (0.000)	**53.6 (0.13)**	Total Train KM	
				0.002 (0.00)	
9	Track	0.80 (0.000)	**3.19 (0.64)**	Equated Track	
				0.019 (0.00)	
10	S&T Maintenance	0.54 (0.000)	**12.99 (0.24)**	TKM(Goods)	TKM(Passenger)
				0.001(0.06)	0.005 (0.10)
11	Operating Cost Fuel (Diesel)	0.65 (0.000)	**103.2(0.12)**	**Goods GTKM**	Passenger GTKM
				0.005 (0.130)	0.011 (0.0)
12	Operating Cost Other Than Fuel (Diesel)	0.45 (0.04)	6.165 (0.00)	Goods GTKM	Passenger GTKM
				0.002 (0.67)	0.013 (0.07)
13	Operating Cost Fuel (Electric)	0.62 (0.000)	**103.6 (0.15)**	**Goods GTKM**	**Passenger GTKM**
				25.79 (0.29)	**79.23 (0.11)**
14	Operating Cost Other Than Fuel (Electric)	0.77 (0.000)	**7.8 (0.29)**	Goods GTKM	Passenger GTKM
				4.8 (0.07)	9.9 (0.06)

Note: p value of 0.1 indicates that the coefficient is significant at 90 % significance level. All estimates which are not significant at 90 % (p values > 0.1) are given in bold.

Above table shows that all the 14 models are significant with R Squared ranging from 0.8 to .45. Though are R squared values are not high in some cases, the significance of the model indicates that predictors have an important say in expenditure. Moreover, bringing in additional variables can improve predictability.

Intercepts are significant for 5 out of the 14 estimates. In the 14 equations, 22 predictors are used - with 8 equations having 2 predictors and 6 equations having one predictor. Out of the 22 predictors 18 predictors are significant and 4 are non-significant.

The above is a pointer to the robustness of the approach but highlights further work to be done. However, the estimates indicate that it is possible to deepen the analysis and develop a more disaggregate approach to costing.

4.3.1 Unit Costs: Comparison with IR Unit Cost

An important validation of the approach can be whether one can replicate the unit costs estimated by present method with those obtained by IR. The data for IR unit costs was obtained from the costing books published by IR for 2006-2007 (Railway Board, 2007). The results, presented in Table 6 , show a close match with each other. Differences, except unit costs on signalling and Telecommunication (S&T), are less than 10 %; track O&M costs and wagon O&M costs differing by 1 % and cost of other transportation, cost of electric loco operation and O&M and diesel loco operation and O&M differing by 3, 8 and 7 % respectively. S&T costs, however, vary by 52 %. This difference may have arisen because the performance measures were not consistent and authors could not get more reliable information for S&T performance measures for the year under consideration.

Table 6: Comparison of freight unit costs: Statistical approach and IR approach

Sl. No.	Elements of costs	Freight unit costs (in Rs)		% of difference
		Statistical (present) method	IR method*	
1	Diesel Loco-R&M, POH Operating Cost Other than Fuel per 1000 gtkms	41.34	39.56	
	Fuel and fuel related Operating exp. cost per 1000 gtkms	102.40	93.81	
	Total Working expenditure of Diesel Loco	143.74	133.37	-8
2	Electrical Loco-R&M, POH, OHE and Operating other than Energy.	19.34	23.92	
	Energy cost per 1000gtkms	51.45	52.25	
	Total Working expenditure of Electrical Loco	70.79	76.17	7
3	O&M Cost of Track per 1000 gtkms	29.94	30.23	1
4	O&M Cost of Other transportation per 1000gtkms	36.72	35.80	-3
5	O&M Cost of S&T per Train km	16.59	10.91	-52
6	O&M Cost of Wagons.	146.22	146.97	1

Source for IR unit costs: ** IR unit cost estimates for 2006-07

5. Developing of capital costs

Assets are acquired and used on a continual basis and estimating the cost of capital for a particular year becomes difficult. Keeping the complexities in view, Indian Railway adapts a much simplified process to estimate the capital and interest costs. This is done by assigning the depreciation reserve fund (DRF) of each year under various heads. However, as Railway does not have a consistent policy for fixing DRF the capital costs are arbitrary and vary from year to year drastically.

Alternatively, the annual depreciation of the asset is arrived at by assuming straight line method of depreciation, i.e. by dividing the current asset value by asset life. The depreciated cost and the annual interest are taken as the annual cost of capital used. Table 7 gives depreciation and interest values and also unit costs with reference to relevant performance measures.

Table 7: Annual depreciation and interest of capital deployed

Sl. No.	Item of capital	Depreciation	Interest	Total	Unit of measurement	Cost per unit
		Rs	Rs	Rs		Rs
I	Rolling Stock:					
a	Loco – Diesel per loco	1392334	3258061	4650395	1000 gtkms	27.04
b	Loco - Electrical per loco	1650308	3754450	5404757	1000 gtkms	24.17
c	Wagons per one wagon	28055	60513	88568	Wagon day	243
d	Coaches per one coach	120678	235322	356000	Vehicle day	975
II	Track per km	346570	2292366	2638936	1000 gtkms	140
III	Overhead Equipment per km	114900	298740	413640	1000 gtkms	17.97
IV	S & T per km	88850	144382	233232	1000 gtkms	12.39

6. Discussion

The approach and the results described above can be used for a number of purposes. Here we illustrate through examples a few areas of application:

- Finding the incremental or long run marginal cost by segregating variable and fixed costs
- Assigning costs as per sectional characteristics
- Comparing and benchmarking performance of entities in IR
- Automating the whole costing methodology

6.1 Estimation of fixed and variable costs

In the current IR approach estimating variable and fixed costs is very arbitrary and thus it is necessary to have a method with which the segregation can be done on a more methodical basis. In the current method for each expense category a linear equation was set up with a constant and coefficients associated with output measures. The linear equation can be used to segregate fixed and variable costs and we illustrate a case with diesel costs.

6.1.1 Diesel repair and maintenance: Segregating fixed and variable costs

As explained earlier, expenses for repair and maintenance of locos in sheds is regressed with passenger and goods loco holding of the shed and the regression parameter estimates are given in Table 8. Intercept is treated as the fixed cost and the coefficients are treated as variable cost.

Table 8: Parameter estimates for repair and maintenance of diesel locomotives

Units	Value Estimate
Fixed Cost (Intercept)	Rs 6.5 crores
Variable Cost (Passenger)	Rs 0.23 crores per annum per passenger loco

Variable Cost (Goods)	Rs 0.186 crores per annum per goods loco

Using the above information unit variable and fixed costs for repair and maintenance of a diesel locomotive are given in Table 9.

Table 9: Calculation of unit fixed and variable costs per gross tonne kilometre for repair and maintenance of diesel locomotive

Fixed cost per shed per year = 6.50 crores
Variable cost per Goods Loco per year = 0.18 crores
Number of sheds = 34 Units
Number of effective loco = 3398 units
NTKM/Loco/Day/on Line = 2, 61,041 kms
Total fixed cost for Diesel Loco Repair & Maintenance per year=6.50 crs×34= 221 crs
Total fixed cost/loco/day= (Rs. 221 crs ÷ (3398 × 365)) × 10000000 = Rs 1781.87
Variable cost of goods locos = (0.18 crs ÷ 365) × 10000000 = Rs. 4931.50
Fixed cost per NTKM = Rs. 1781.87 ÷ 2, 61,041 = 0. 6 paisa
Variable cost per NTKM = Rs 4931.50 ÷ 2, 61,041 = 1.8 paisa

Using similar approach, variable and fixed costs for each expense category is given in Table 10

Table 10: Proportion of fixed and variable components of operational expenditure

Elements of costs	Fixed expenditure (in Rs Crores)	Variable expenditure (in Rs Crores)	Total expenditure (in Rs Crores)	% of fixed expenditure
Diesel Loco: R&M, POH,	374	1050	1424	0.26
Diesel Loco: Fuel Related Operating Expenses	1238	4285	5523	0.22
Diesel Loco: Operating Exp. Other than Fuel	99	1216	1315	0.08
Electrical Loco: R&M, POH, OH Equipments	392	1581	1973	0.20
Electrical Loco: Fuel Related Operating Expenses	1243	4343	5586	0.22
Electrical Loco: Operating Exp. Other than Fuel	92	694	786	0.12
Permanent Way-Track	239	2117	2356	0.10
Signal & Telecommunications (S&T).	208	731	939	0.22
Cost of Other Transportation	804	2506	3310	0.24
Cost of Carrying Units: Wagons	470	2218	2688	0.18
Vehicles	332	1685	2017	0.16
Terminal Expenses	671	2863	3534	0.19
Overhead Expenditure	724	3088	3812	0.19
Total Expenditure	6888	28377	35265	0.20

The above costs can be converted to unit fixed and variable unit costs as was done for diesel locomotive.

6.2 Sectional Cost

An important issue for policy makers and transport professionals would be to simulate the costs as per the route. To arrive at route specific costs, it is imperative to relate the unit costs to different types of sections and build a route level cost. However, as IR has large number of sections, representative sectional types are developed to cover all types of sections in IR and data is built for a sample of these representative sections to develop sectional costs.

Three criteria are used to choose representative sections. They are i) number of lines, ii) traction and iii) gradient. Number of lines in the section is important as capital and operations costs vary based on the number of lines in the section; hence single line and double line or multiple lines are taken as two categories.

As traction is another important driver of costs electric and diesel sections are taken as two categories. Gradient of a section is another critical element in deciding capital and operational costs because speed of movement, tractive effort required and detention hours vary with the gradient. Based on these criteria sections were divided into two categories; plain sections with gradients less steep than 1 in 100 and ghat sections with steeper gradients.

All the three criteria have two sub-categories giving rise to 8 (2*2*2) different combinations to identify variations in sectional costs and the 8 sub-categories are listed in Table 11.

Table 11: List of representative sectional types used for sectional costing

1	Single line-diesel-plain	2	Double line-diesel-plain
3	Single line-elec-plain	4	Double line-elec-plain
5	Single line-diesel-ghat	6	Double line-diesel-ghat
7	Single line-elec-ghat	8	Double line-elec-ghat

The sectional costs vary due to sectional speeds, requirement of additional locomotives for movement and additional time spent for safety examination. All these factors were considered in estimating the sectional costs. Sectional speed and detention data were obtained from freight operating information systems (FOIS) for train running data base for large sample of sections.

The data on requirement of additional locomotives and additional train examinations is obtained from working time tables, FOIS information and discussions with the zonal operating teams.

Using the above data, the average Sectional Unit Costs are estimated for Indian Railways. The unit costs are then converted to cost per tonne-km (tkm) for freight services and they are given in Table 12..

Table 12: Sectional costs for movement of cargo

Units: Rs. per TKM

Sl. No.	Elements of costs	Plain section				Ghat section			
		Unit cost for diesel		Unit cost for elect.		Unit cost for diesel		Unit cost for elect.	
		SL	DL	SL	DL	SL	DL	SL	DL
1	Line-haul operational Costs	0.34	0.30	0.23	0.21	0.62	0.54	0.37	0.32
2	Terminal Cost	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03
3	Overhead Cost	0.045	0.045	0.045	0.045	0.04	0.04	0.04	0.04
4	Total of O&M Costs	0.41	0.37	0.30	0.28	0.69	0.61	0.44	0.39
5	Capital Costs	0.26	0.27	0.28	0.29	0.29	0.30	0.31	0.32
6	Total Fully-distributed Costs	0.66	0.63	0.57	0.54	0.97	0.91	0.75	0.71

Note: Totals may not match due to rounding of errors.

6.3 Comparing and benchmarking performance

As discussed in the introduction section, currently IR aggregates expenses at the zonal level. In the process of aggregation valuable information is lost as data over various expense categories get merged. This complicates comparing of how different units perform.

In the proposed methodology data for similar cost drivers is segregated and tools applied to arrive at the cost. Thus in the current approach costs incurred in different sheds, workshops can be compared with similar units. This can help in benchmarking various entities based on the costs.

6.4 Automating the costing process

Currently there is a time gap of nearly two years between the incurrence of expenditure and printing the cost data. As the proposed process is dependent on statistical tools built on data which is already computerised the gap can be reduced substantially. Further, the whole process can be automated to reduce the time gap further.

7. Relevance of the study and further work

The above exercise demonstrates an alternative approach to develop costs for IR. The proposed method is disaggregate and relates costs to accounting units where expenses are incurred. It also uses statistical methods to arrive at the costs. The proposed approach helps in:

- Relating costs to relevant cost drivers more closely
- Analyses data at a more disaggregate level linking costs to performance of 162 accounting units compared to the current approach where costs are estimated for 16 zones.
- The proposed approach has stronger methodological foundation as it is based on robust statistical methods compared to current approach.

The proposed methodology has great relevance in the current context as costing and pricing are under focus in recent times. IR has taken up accounts reforms project in which arriving at costs of operations is an important terms of reference. The current approach will help in meeting some of the objectives of the project.

Similarly, Government of India set up Rail Development Authority (RDA) (Press Information Bureau, 2017) and amongst other objectives the following are directly related to costing of services:

- Pricing of services commensurate with costs.
- Protection of consumer interests, by ensuring quality of service and cost optimization.
- Promoting competition, efficiency and economy.
- Encouraging market development and participation of stakeholders in the rail sector and for ensuring a fair deal to the stakeholders and customers.
- Creating positive environment for investment.
- Promoting efficient allocation of resources in the Sector.
- Providing framework for non-discriminatory open access to the Dedicated Freight Corridor (DFC) infrastructure and others in future.

For RDA to achieve these objectives it needs a robust costing methodology and the proposed methodology could be a starting point.

The work can be extended in manifold directions. Some of them are:

- Integrating the current approach into IR costing methodology.
- Integrating with various databases and measures so that various performance measures are easily obtained
- Increasing the accounting units mainly at the divisional level to obtain better disaggregation of costs
- Using data over large number of years enabling use of panel data methods for improving estimation

8. Dedication and Acknowledgements

The paper is dedicated to Sri (late) R. S. Gopalan who expired on 16.07.2010 when he was working as Assistant Manager RITES. Prior to this he worked as Traffic Costing Inspector in South Central Railway. His in-depth knowledge, extensive experience and diligent approach to work were critical in completing the study.

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Notwithstanding the above, two surviving authors take the responsibility for what is presented in the paper.

9. References

Alivelu, G., 2006. Analysis of productivity and costs across the Indian zonal railways 1981-82 through 2002-03, PhD thesis, Centre for Economic and Social Studies, B R Ambedkar Open University, Hyderabad.

Alivelu, G., 2007. The Estimation of Indian Railway Cost Function, Zagreb International Review of Economics & Business; Zagreb 10.1, 11-32. Retrieved 1/10/2017 from: https://hrcak.srce.hr/file/53224

Debroy, B., and Desai., K., 2017. NITI Ayog status update on AR Retrieved September 30, 2017, from: http://niti.gov.in/writereaddata/files/document_publication/Status%20Update%20-%20AR%20in%20Railways_0.pdf

Healey, J., M., 1964. An Analysis of Railway Costs and Prices The Economic Weekly January 4, 1964, 15-20. Retrieved 6/10/2017 from: http://www.epw.in/system/files/pdf/1964_16/1/an_analysis_of_railway_costs_and_prices.pdf

ICAI Accounting Research Foundation (n. d.), Draft Concept Paper on Study of Existing Budgeting and Costing System and Proposal for Outcome Budgeting & Integrated Cost Accounting Architecture. Retrieved September 30, 2017, from: http://www.indianrailways.gov.in/railwayboard/uploads/directorate/acc_ref/Concept_Paper_Outcome_Budgeting_Nov__5.pdf

Koshal, R., K., 1970. Economies of Scale in Rail Transport, Indian Economic Review, Vol. 5, No.2, Oct., pp. 177-91.

Press Information Bureau, 2017. Rail Development Authority. Retrieved October 5, 2017, from: http://pib.nic.in/newsite/mbErel.aspx?relid=168632.

Railway Board, 2003. Handbook on Traffic Costing, Directorate of Economics and Statistics, Ministry of Railways.

Railway Board, 2007, Unit Freight Costs Ministry of Railways, Government of India.

Railway Board, 2015a. Annual Statistical Statement – 2014-15, Ministry of Railways, Government of India. Retrieved September 30, 2017, from http://www.indianrailways.gov.in/railwayboard/view_section.jsp?lang=0&id=0,1,304,366,554,1817,1822.

Railway Board, 2015b. Indian Railways Finance Code Volume-I. Retrieved September 30, 2017, from: http://www.indianrailways.gov.in/railwayboard/uploads/codesmanual/irfc1/Default.htm

Railway Board, 2016. Indian Railways Finance Code Volume – II, Retrieved September 30, 2017, from: http://www.indianrailways.gov.in/railwayboard/uploads/codesmanual/FINANCECODE/finance.htm.

Railway Board, 2017. Zones and Divisions. Retrieved September 30, 2017, from: http://www.indianrailways.gov.in/railwayboard/view_section.jsp?lang=0&id=0,1,304,366,533,1007,1012.

Railway Board (n. d.), Accounting Reforms Project: Status. Retrieved September 30, 2017. from: http://www.indianrailways.gov.in/railwayboard/uploads/directorate/ acc_ref/AR_Project_Status/AR_Action_Plan_LATEST19%20_1_.pdf.

RITES,1980. Total Transport System Study on Traffic Flows and Modal Costs (Highways, Railways, Airways and Coastal Shipping), unpublished, Gurgaon.

RITES, 1988. Total Transport System Study on Traffic Flows and Modal Costs (Highways, Railways, Airways and Coastal Shipping), unpublished, Gurgaon.

RITES, 2009. Total Transport System Study on Traffic Flows and Modal Costs (Highways, Railways, Airways and Coastal Shipping), unpublished, Gurgaon, Retrieved 1/10/2017 from http://planningcommission.nic.in/reports/genrep/ index.php?repts=rites.html.

Varma, H.,O., 1983. *The Study of Cost Function of Indian Railways*, Ph.D Thesis, Department of Economics, Delhi School of Economics, University of Delhi, Delhi.

Varma, H.,O., 1988. *Econometric Cost Functions*, Anmol Publications, New Delhi.

Wilson W. W and Bitzan J., D., 2003. Costing Individual Railroad Movements prepared for Federal Railroad Administration, Retrieved 1/10/2017 from: http://www.ugpti.org/pubs/pdf/DP153.pdf.

Winston, C. 1985. Conceptual Developments in the Economics of Transportation: An Interpretive Survey. *Journal of Economic Literature*, *23*(1), 57-94 Retrieved 1/10/2017 from: https://serviciospublicos.files.wordpress.com/2010/05/winston.pdf.