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A Critical Analysis of Freight Movement by Indian Railways

Dr. M. Sekar
Assistant Professor School of Maritime Management Indian Maritime University, Chennai- 600 119 India

ABSTRACT:
Indian Railways is the backbone of urban transportation and freight movement within the country, one of the biggest employer in the country, of late lot of importance is given for freight movement through the railways as its cheaper, faster, safer and more sustainable than the roadways, also reduces traffic congestion on road and curtail greenhouse gas emission.
This paper critically analyse the freight movement of Indian Railways by analysing three research question that is, whether the earning in freight has any relation to freight traffic of Indian Railways with the distance travelled with cargo (net tonne kilometre), whether freight traffic of Indian railways has any influence with Port throughput and also to find whether the pandemic has affected the movement of rail freight. the author applied simple regression and multiple regression techniques for the study. The outcome of the study shows there is strong relationship exist between earnings and the freight handled but there is no significant relationship between net tonne kilometres (in million) and Earnings (in crores). The Port transports a portion of their volume of cargo through railways, there exist a strong positive correlation between freight transported in Railways and Cargo handled in Ports. The growth rate of railways in transporting goods has hit very hard during 2019-20 was mainly due to pandemic.

Key Words: Railway freight, COVID-19, Tonnes Originating, Earnings on Freight and Net Tonne Kilometres

I. INTRODUCTION:

Indian Railways is the backbone of urban transportation, the biggest employer in the country, of late lot of importance is given for freight movement through the railways as its cheaper and faster than the roadways, the Indian Railways network is one of the longest, ranked fourth in world (Garg and Kashav 2020)

The railway earnings largely depend on rail freight whereas there is no financial benefit in operating passenger train. Operating passenger train is only from the social perspective the Indian railways earns surplus only through the rail freight, railway believes in cross subsidization, hence analysing the freight movement through Indian railways is quite significant. Whether it's a container movement, bulk cargo or liquid bulk, moving cargo through rail is economical compared to road mode, provided the movement of cargo is more than 180 kilometres. Any transporter who wants to transport large volume of cargo for a long haul usually prefers rail mode as it cost effective, saves time and safer compared to road mode. Rail mode is also preferred mode because it is more sustainable, reduces traffic congestion on road and also curtail greenhouse gas emission. For Multimodal transporters railways plays an important role in shipping containers on time, rail freight has become an important mode helping the supply chain to evolve efficiently, so the author finds that a study on to critically analyse the freight movement of Indian Railways could be interesting.

The scope of the study is to critically analyse the freight movement of Indian Railways using variables like tonnes originating, net tonne kilometre, earnings in freight and Indian port throughput for a period between 2011-12 to 2019-20. The author makes an effort to analyse three research question that is, whether the earning in freight has any relation to freight traffic of Indian Railways (tonnes originating) and the distance travelled with cargo (net tonne kilometre), whether freight traffic of Indian railways has any influence with Port throughput and also to find whether the pandemic has affected the movement of rail freight. The data is collected from the secondary source for the period 2011-12 to 2019-20. For finding whether the earning in freight has any influence on freight traffic and distance travelled with cargo, the author calculated simple regression, in model-1, marking earnings as dependent variable and tonnes originating as independent variable. In model -2 the study is done using multiple regression, designing earnings as dependent variable and tonnes originating and net tonne kilometres as independent variables. To examine the relationship between freight transported in Indian Railways and Cargo handled in Ports, the author applied Pearson's Correlation method. For finding whether pandemic has any influence on the growth of rail freight, growth rate in percentage is calculated on tonnes originating.

The Study has some limitation, the author tried to collect information relating to 2020-21, the details are not yet published, hence unavailability of data for 2020-21 may be considered as a limitation.

II. LITERATURE REVIEW:

The Indian Railways plays an important role in the country, by contributing to the infrastructure development of the country since 1850. The Railways is one the biggest logistics provider for both passenger and cargo, as per the vision 20 document the Railways started focusing more on Capacity development, safety factors, developing railway network, introduction of bullet trains, in short, developing state of the art infrastructure (Sunil Kumar Sharma1 * and Anil Kumar 2020)

Moving cargo through truck causes problems like traffic blockages on roads, high fuel consumption etc., whereas moving cargo through the railways can solve these problems Lesmini. et al deliberates on applying qualitative approach to converge logistics park with cargo movement by railways.(Lis Lesmini1, Raden Didiet Rahmat Hidayat2 2017)

The COVID-19 had influenced the transport sector, this crisis showed the new strategy to approach the transport industry. Due to the pandemic outbreak the industry learned to work on digital platforms, the good news during pandemic is the carbon foot prints remained low due to shut down of many industries including transport sector. At the same time low usage of rail mode can ruin the urban transportation (Tardivo, Sánchez Martín, and Carrillo Zanuy 2020).

The introduction of containers have dramatically altered the rail freight operation, this leads to phenomenal growth in the railway freight stations which handles containers (Kai and Li 2019)

Rail transportation plays a key role in transporting goods between Major Ports in Britain and its hinterland, to witness growth in Rail mode the sector should able to solve the bottle necks which comes in between (Woodburn 2007).

Transporting dangerous goods through rail mode should be done with utmost care, the study focuses on important criteria to be followed in transporting dangerous goods and also analyses the important feature to be considered while transporting the dangerous goods through railways so that it is operated with absolute safety (BatarlienËe 2020).

In this case, the containers are shifted to railway yard from many ports, thereafter the cargo is dispatched to its hinterland, the entire movement is done through rail mode. A mathematical decision tool is developed for effective and efficient functioning of its operation (Hu et al. 2019).

Since Indian Railways requires huge investment for its expansion and its operation, moreover passenger trains are running in loss cross subsidizing to freight trains, private players may be roped in to invest in railways (Parry. and Kadakol. 2017)

It is better to transfer 30% of the cargo from road mode to rail mode or inland water mode when the distance is more than 300 kms, this shall improve the efficiency and reduce carbon foot prints (Tno 2011)

Decrease in vehicle Kms may bring down the traffic congestion, carbon foot prints and noise pollution around Paris, this can be achieved by substituting rail mode into the fray (Maes and Vanelslander 2011)

Though rail transport is highly capital demanding than other transport mode it is more friendly when traffic congestion in roads are considered and is one of the more energy efficient transportation for both freight and passenger (Choudhary and Rao 2018)

This paper examines the series of class of services that railways should adopt for its efficient operation (Premkumar and Kumar 2019)

The paper examines the benefits of shifting containers from road mode to rail mode in south Korea, by some solid preferment policies. One of the outcome from the study is transport packaging meant for containers serves as a preferment policy to shift from road mode to rail mode, financial assistances were given in the form of subsidies to encourage modal shift (Choi, Park, and Lee 2019)

The paper examines moving containers in Eurasia through, road, rail and sea transport three-dimensional model, four different situations are analysed and empirically verified with intermodal networks to find the competition arrangement among them (Lu et al. 2019).

The paper analysis the distance as a significant criterion for selecting intermodal or a single mode of transportation when shipping cargo the outcome of the study is that intermodal transport may deliver a viable alternative to single road mode transportation (Zgonc, Tekavčič, and Jakšič 2019).

While going through the above literature there is not such contemplation which is analysing the earnings in freight of railway with relation to freight traffic (tonnes originating) and the distance travelled with cargo (net tonne kilometre), so this gap is filled in this study.

III. MATHEMATICAL MODELLING:

Multiple Regression and Simple Regression

The author used multiple regression and simple regression technique to analyse the relationship between earnings, tonnes originating and Net Tonne kilometres.

In model-1, a simple regression is calculated keeping earnings as dependent variable and tonnes originating as independent variable.

i.e., $\hat{y}=b_0+b_1x_1$
$\hat{y}$= Earnings (in crores)
$x_{1=}$ Tonnes Originating (in million)

In Model-2 the analysis is done using multiple regression marking earnings as dependent variable and tonnes originating and net tonne kilometres as independent variables.

i.e., $\hat{y}= b_0+b_1x_1+b_2x_2$
$\hat{y}$= Earnings (in crores)
x_1= Tonnes Originating (in million)
x_2 = Net Tonne kilometres (in million)

Hypothesis test of significance for the individual parameters is also calculated.
$H_0 : \beta_i=0$
Ha : $\beta_i\neq0$
If slope is equal to 0 then there is no relationship between x and y
Beta 'i' is the generic representation of the hypothesis

Rejection Rule:
Reject H_0 if p-value $\leq \alpha$ or if $t \leq -t_{\alpha/2}$ or $t \geq t_{\alpha/2}$
Where $t_{\alpha/2}$ is based on t distribution with n-p-1 degrees of freedom
The study rejects the null hypothesis if the p-value is less than are equal to alpha

Pearson's Correlation

Since a major portion of the cargo are evacuated and dispatched by Indian railways in Major and Non-Major ports, the author tries to find out whether there is any correlation between freight transported in Indian Railways and Cargo handled in Ports. So Karl Pearson's Correlation is applied to find the relation between two variables i.e., Freight traffic of Indian Railways (Tonnes Originating) and Cargo Handled at Ports.

$$r = \sum dxdy/\sqrt{\sum dx^2}\sqrt{\sum dy^2}$$
Where $dx = (X - \overline{X}), dy = (Y - \bar{Y}),$

The Pearson's correlation is calculated by using excel.

IV. ANALYSIS AND ELUCIDATION:

Data are collected through the secondary sources analysed as follows: -

a. Earnings and Freight Traffic of Indian Railways (Model-1)

In any logistics sector, usually the earning is dependent on freight unless the company has a multiple business, hence the author makes an effort to find whether the Railways earning is directly connected to the freight handled (Tonnes Originating) and how it is related.

Table-1 Statement Showing Earning and Freight Traffic of Indian Railways

Year	Tonnes Originating (in million)	Earnings (in crores)
	(a)	(b)
2011-12	969.05	67743.62
2012-13	1008.09	83478.83
2013-14	1051.64	91570.85
2014-15	1095.26	103100.15
2015-16	1101.51	106940.55
2016-17	1106.15	102027.82
2017-18	1159.55	113523.53
2018-19	1221.48	122580.31
2019-20	1208.41	111472.30

Source: Various Annual Report and Accounts of Indian Railways

The author makes an attempt to find out whether earnings is dependent on freight traffic of railways, hence a simple regression is calculated (Model-1) keeping earnings as dependent variable and tonnes originating as independent variable

$\hat{y}=b_0+b_1x_1$

Correlation Coefficient-r

$-1\leq r\leq+1$

Multiple R = 0.953

Coefficient of determination r^2 is 0.909 which tells the percent of variation in y which is explained by the x variables.

Table-A

Calculated Values		
	Coefficient	**P-Value**
Intercept	-107732	0.0034011
X Variable 1	188.69	6.67023E-05

$\hat{y}=b_0+b_1x_1$

$\hat{y}=-107732+188.69x_1$

b_0=-107732 Y-intercept. This is the value of y when the x is 0

b_1=188.69 Slope for "tonnes originating (in million)" this is expected increase in Earnings (in crores) corresponding to a one-unit increase in "tonnes originating (in million)"

Hypothesis testing for β_1

$H_0: \beta_i=0$

$Ha: \beta_i\neq0$

$\alpha= .05$

P-value $\leq \alpha$

We want to find evidence for the alternate hypothesis that the slope is not equal to zero and that would give evidence of a relationship between x and y between tonnes originating (in million) and Earnings (in crores)

The P-value is very small, it is so small that it is written in scientific notation, therefore we would reject the null hypothesis and find evidence of significant relationship between tonnes originating (in million) and Earnings (in crores)

b. **Earnings, Freight Traffic and Net Tonne Kilometres of Indian Railways (Model-2)**

The following table explains the earnings of railways vis-a- vis tonnes originating and Net Tonne Kilometres. Net Tonne kilometre is calculated by multiplying the tonne carried by railways with distance travelled in kilometre. The table also show earnings (crores) per tonne (million) which is calculated by dividing Earnings by Freight Traffic (Tonnes Originating).

Table-2 Statement Showing Earnings and Freight Traffic of Indian Railways

Year	Tonnes Originating (in million)	Net Tonne kilometres (in million)	Earnings(in crores)	Earnings per (million) tonne(in crores)
	(a)	(b)	(c)	(d)=(c)/(a)
2011-12	969.05	667607	67743.62	69.91
2012-13	1008.09	649645	83478.83	82.81
2013-14	1051.64	665810	91570.85	87.07
2014-15	1095.26	681696	103100.15	94.13
2015-16	1101.51	654481	106940.55	97.09
2016-17	1106.15	620175	102027.82	92.24
2017-18	1159.55	692916	113523.53	97.90
2018-19	1221.48	738523	122580.31	100.35
2019-20	1208.41	707665	111472.30	92.25
(Source: Various Annual Report and Accounts of Indian Railways)				

In Model-2 the study is done using multiple regression keeping earnings as dependent variable and tonnes originating and net tonne kilometres as independent variables

$\hat{y}= b_0+b_1x_1+b_2x_2$

Correlation Coefficient-r
$-1 \leq r \leq +1$
Multiple R = 0.96
Coefficient of determination r^2 is 0.9228 which tells the percent of variation in y which is explained by the x variables.
Adjusted R Square is 0.8971 which adjust for the number of terms in a model.

Table-B

Calculated Values		
	Coefficient	**P-Value**
Intercept	-79827.87	0.075213163
X Variable 1	208.63	0.000430955
X Variable 2	-0.0738	0.35195287

$\hat{y} = b_0 + b_1x_1 + b_2x_2$
$\hat{y} = -79827.87 + 208.63x_1 - 0.0738x_2$
$b_0 = -79827.87$ Y-intercept. This is the value of y when all the x's are 0
$b_1 = 208.63$ Slope for "tonnes originating (in million)" this is expected increase in Earnings (in crores) corresponding to a one-unit increase in "tonnes originating (in million)"
$b_2 = -0.0738$ Slope for "net tonne kilometres (in million)" this is expected decrease in Earnings (in crores) corresponding to every one-unit of "net tonne kilometres (in million)" when the other independent variables do not change.

Hypothesis test of significance for the individual parameters:
Hypothesis testing for β_1
$H_0 : \beta_i = 0$
$Ha : \beta_i \neq 0$
$\alpha = .05$
p-value $\leq \alpha$
The study tries to find evidence for the alternate hypothesis that the slope is not equal to zero and that would give evidence of a relationship between x and y between tonnes originating (in million) and Earnings (in crores) When we look into p-value it is found that the p-value is very small therefore reject the null hypothesis and find evidence of significant relationship between tonnes originating (in million) and Earnings (in crores)
Hypothesis testing for β_2
p-value is not $\leq \alpha$
From the table it is found that P- value is greater than α and therefore do not reject the null hypothesis and it is found evidence that there is no significant relationship between net tonne kilometres (in million) and Earnings (in crores).
This section further explores by calculating earnings (crores) per tonne (million) to find out which year the earnings (crores) per tonne (million) is the highest. Analysing table-2, it may be inferred that Earnings (in crores) per Tonnes (in million) is highest in 2018-19, (100.35) followed by 2017-18 (97.90). There is a steady growth in Earnings (in crores) per Tonnes (in million) since 2011-12 onwards except a small fall in 2016-17. There is a big dip during 2019-20 which can be construed due to pandemic.

c. **Freight Traffic of Indian Railways and Cargo handled at Ports:**

The railway freight traffic largely depends on moving goods from ports to hinterland and hinterland to ports. Around 26% of the cargo handled in ports are evacuated by railways. Indian railways serve in evacuating and despatching cargo from Major as well as Non Major Ports. Ports like Chennai Port, JNPT, Mundra Port, Kandla Port are well connected to railways main line. The author makes an attempt to find whether there is any correlation between freight transported in Indian Railways and Cargo handled in Ports. Hence applied Pearson's Correlation techniques to measure whether there is any relation exists between Freight traffic of Indian Railways (Tonnes Originating) and Cargo Handled at Ports.

Table-3 Statement Showing Freight Traffic of Indian Railways and Cargo handled at Port

Year	**Tonnes Originating (in million)X**	**Cargo Handled in Ports (in million Tonnes)Y**
2011-12	969.05	913.93
2012-13	1008.09	933.75
2013-14	1051.64	972.46
2014-15	1095.26	1052.23

2015-16	1101.51	1071.76
2016-17	1106.15	1133.69
2017-18	1159.55	1208.56
2018-19	1221.48	1281.78
2019-20	1208.41	1319.97
Source: Indian Railways Annual Report and Accounts and Basic Port Statistics, Ministry of Ports, Shipping & Waterways		

Calculation:
X= Freight traffic of Indian Railways (Tonnes Originating)
Y= Cargo Handled at Ports (in million tonnes)
$\bar{X}$ = Mean value of X
$\bar{Y}$ = Mean value of Y

$\sum dxdy$ =98626.93

$\sqrt{\sum dx^2}$
$\sqrt{\sum dx^2}$ = 240.84
$\sqrt{\sum dy^2}$ = 419.45
$r = \sum dxdy / \sqrt{\sum dx^2}\sqrt{\sum dy^2}$
Where $dx = X - \bar{X}, dy = Y - \bar{Y}$,
r = 0.9763
The Value of r=0.9763
From the calculated values it is very clear that there is a Strong Positive Correlation between Freight traffic of Indian Railways (Tonnes Originating) and Cargo Handled at Ports. In other words, 'X' variable scores are correlated with 'Y' variable score (and vice versa).

d. **Impact of COVID-19 on Rail Freight:**

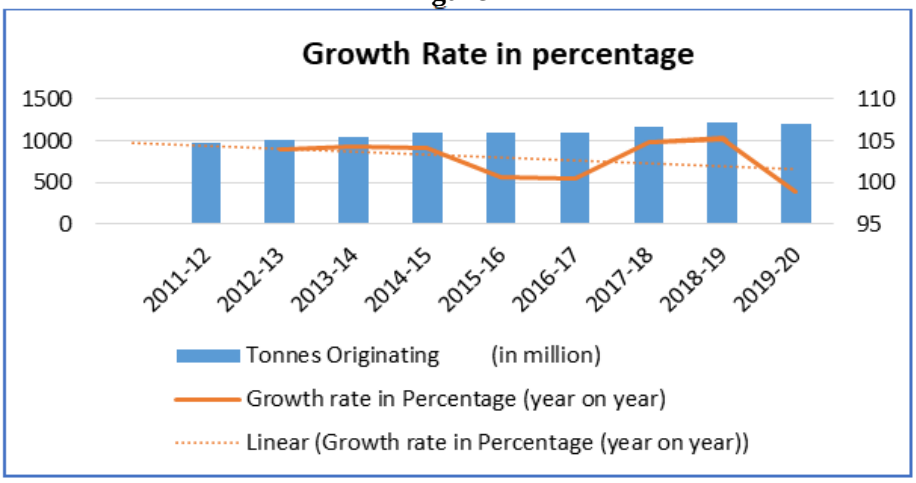
During the current situation, pandemic, the study should also analyse the performance of rail traffic during COVID-19.

Table-4 Growth Rate in percentage

Year	**Tonnes Originating (in million)**	**Growth rate in Percentage (year on year)**
2011-12	969.05	NA
2012-13	1008.09	104.03
2013-14	1051.64	104.32
2014-15	1095.26	104.15
2015-16	1101.51	100.57
2016-17	1106.15	100.42
2017-18	1159.55	104.83
2018-19	1221.48	105.34
2019-20	1208.41	98.93

(Source: Various Annual Report and Accounts of Indian Railways)

Figure-1



The COVID has a big impact on rail freight, the pandemic has hit hard during 2019-20 onwards, from the above table it clear that the growth rate in percentage has diminished from 105.34% during 2018-19 to 98.93% in 2019-20 which means during 2019-20 the pandemic pulled down the rail freight significantly. Before pandemic, it is seen that there is a steady growth in rail freight from 20011-12 onwards, essentially the fall is from the year 2019-20.

V. DISCUSSION:

The author makes an attempt to find whether the Railways earning is directly associated to the freight handled (Tonnes Originating) and how it is connected. In Model-1 a simple regression technique is used and discussion on the result are as follows: -

Slope for "tonnes originating (in million)" this is expected increase in Earnings (in crores) corresponding to a one-unit increase in "tonnes originating (in million)"

The author wants to find evidence for the alternate hypothesis that the slope is not equal to zero and that would give evidence of a relationship between x and y between tonnes originating (in million) and Earnings (in crores).

The P-value is very small, it is so small that it is written in scientific notation, therefore we would reject the null hypothesis and find evidence of significant relationship between tonnes originating (in million) and Earnings (in crores).

In Model-2 the study is done using multiple regression keeping earnings as dependent variable and tonnes originating and net tonne kilometres as independent variables. The study tries to find evidence for the alternate hypothesis that the slope is not equal to zero and that would give evidence of a relationship between x and y between tonnes originating (in million) and Earnings (in crores).

If one looks into the p-value it is found that the p-value is very small therefore reject the null hypothesis and have a proof of significant relationship between tonnes originating (in million) and Earnings (in crores)

Hypothesis testing for β_2

p-value is not $\leq \alpha$

From the table it is found that P- value is greater than α and therefore do not reject the null hypothesis and it is found that there is no significant relationship between net tonne kilometres (in million) and Earnings (in crores).

Financially analysing table-2, it may be inferred that Earnings (in crores) per Tonnes (in million) is highest in 2018-19, (100.35) followed by 2017-18 (97.90). There is a stable growth in Earnings (in crores) per Tonnes (in million) since 2011-12 onwards except a small fall in 2016-17. There is a huge fall during 2019-20 this fall in growth rate is essentially due to pandemic.

Further critically analysing the railway freight movement the author makes an attempt to find whether there is any correlation between freight transported in Indian Railways and Cargo handled in Ports. So to find the correlation between the above refereed variables, Pearson's Correlation is applied to measure whether there is any relation exist between Freight traffic of Indian Railways (Tonnes Originating) and Cargo Handled at Ports. The calculated Value is r=0.9763 which means that there is an evidence of Strong Positive Correlation between Freight traffic of Indian Railways (Tonnes Originating) and Cargo Handled at Ports. When analysed whether the cargo movement through rail is affected due to pandemic or not the growth rate in percentage is calculated and it is found that the COVID-19 had a significant impact on rail freight, the pandemic has hit hard

during 2019-20, from the table-4, it clear that the growth rate in percentage has diminished from 105.34% during 2018-19 to 98.93% in 2019-20 which means that during 2019-20 the pandemic has pulled down the rail traffic significantly. Before pandemic, it is visible that there is a steady growth in rail freight from 20011-12. Onwards.

VI. CONCLUSION:

Critically when it is analysed, in any transport mode, earnings are largely dependent on volume of freight carried and the distance covered but what has to be analysed is whether the particular mode earns a significant earning without any spillage of funds. In the above study there is very strong relationship exist between earnings and the freight handled but there is no significant relationship between net tonne kilometres (in million) and Earnings (in crores), from the table-2, b_2= -0.0738, Slope for "net tonne kilometres (in million)" is expected decrease in Earnings (in crores) corresponding to every one-unit of "net tonne kilometres (in million)" which means that the pricing of railway freight with reference to distance covered and volume of freight carried has to be optimized and rationalized. The Port transports a portion of their volume of cargo through railways, there is a very strong positive correlation between freight transported in Indian Railways and Cargo handled in Ports. This is due to the fact that transporting goods through rail mode is more convenient for ports because evacuation and despatch of cargo is faster and economical. The growth rate of railways in transporting goods has hit very hard during 2019-20 is essentially due to pandemic.

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Author: Dr. M. Sekar
Assistant Professor School of Maritime Management Indian Maritime University, Chennai- 600 119 India

**Corresponding Author: Dr.M.Sekar [1]*