Constructing a Method to Calculate Passengers Travel Distance with the Use of Revenue

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ABSTRACT

Performance indicators evaluate the success of an organization or of a particular activity in which it engages. Choosing right performance indicators relies upon good understanding of what is important to the organization. The Ceylon Government Railway (CGR) has recently identified that the passengers' travel distance as one of key performance indicators which measures success in their operations. Even though it was an important indicator, the existing method to measure this distance is not appropriate due to current changes in the revenue. Therefore, the present study attempted to construct a formula to find passengers' travelling distance per month per station with the use of issued tickets and revenue.

Revenue per passenger (per month) was identified as an appropriate index to divide 307 railway stations into nine homogeneous groups in order to select representative sample of stations.45 stations were selected through stratified sampling technique considering revenue per passenger group as stratum. The distance travel by the passenger was divided into five categories, which are called zones. Zone wise percentage contribution to a monthly total revenue and number of ticket issued at a particular station was calculated. Formula corresponding to each zone was introduced with the use of these percentages. Finally, mean absolute error was calculated for both new formula and existing formula and compared the accuracy of predicting passengers' travel distance.

The study revealed that the formula introduced here predicted passengers' travel distance more accurate than the existing one. Therefore, CGR can utilize new formula to measure their performance and thereby can take necessary actions to maintain performance at required level.

KEYWORDS: Economy Class, Revenue, Revenue per passenger groups, Zone

INTRODUCTION

Famous saying like 'Anguru kaka wathura bebee kolamba duwana yakada yaka' (The iron demon who runs to Colombo eating coal and drinking water) is no longer a reality. Trains which ran on steams and power in the past, move on with Diesel. Railway is the premium national transportation medium which provides travelling facilities to thousands of people who come to the capital from various parts of the country. More than three hundred thousand people use trains as their main mode of transport.

If not the Railway, thousands of man hours will be lost for the country, and that will be a big loss in the development of the country. Ceylon Government Railways (CGR) would not be able to provide better service to their passengers, if they could not perform their operations well. The CGR seeks high performance in order to provide good services to passengers. To measure the performance at CGR, they looked for several indicators. One among those, the passengers' travelling distance per month, takes an important place in measuring the performance.

LITERATURE REVIEW

Most of the researches done on railway system have mainly been focused on operational planning problems such as line

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planning, timetabling, plat forming, rolling stock circulation, shunting and crew planning. There were few studies that had touched on measuring performance of the railway system. Laporate (2007) has identified that Railway transportation can be split into passenger transportation and cargo transportation. Measures of rail usage are key indicators of the levels of rail use in Great Britain. They show the number of passengers using the network and journeys made on it, providing an indication of the levels of demand for rail travel. This can help in both short-term and long-term planning for the industry and wider stakeholders, both at a National level and within the rail sectors. The measures are as follows,

- Timetabled train kilometers (TTKM) – the number of train kilometers each train operator would achieve if they operated 100% of their timetable.
- Passenger kilometers – the number of kilometers travelled by passengers on the network.
- Passenger journeys – the number of passenger journeys made on the network.
- Passenger revenue – all ticket revenue and miscellaneous charges associated with passenger travel on national railways, but not including government support or grants.

Passenger kilometers and data of passenger journeys are linked, as the number of journeys made by a passenger impacts the number of kilometers travelled. For example, if the number of passenger journeys increases, you will expect to see an increase in the number of passenger kilometers travelled. Passenger revenue data provides an insight into revenue levels within the industry as well as the levels of revenue generated through each ticket type, which can highlight changes in ticket purchasing trends. An increase in passenger revenue is generally a direct consequence of increased passenger journeys. The percentage change in passenger revenue can often outstrip the equivalent passenger journeys and passenger kilometer measures as a result increases of the fare usually announced in January each year. (Lindop, 2014)

RESEARCH PROBLEM

Selection of performance indicators depends on what is important to the organization and its operations. In early decade, CGR has used two particular methods to measure the performance of the railway system. Those are calculating kilometers that the trains travelled and calculating kilometers that the wagons travelled. Later, they understood that those two methods were inappropriate, and had identified that the total number of kilometer that the passengers travelled was a good indicator to measure the performance of CGR. To meet the demand of calculating distance travelled by passengers, the manual method was used and it became problematic and complicated. Therefore, since 2010, CGR is using a formula given under Equation 01 to calculate travelling distance by passengers under ordinary tickets.

$$Passengers\ travelled\ Kilometers = \frac{Ordinary\ Ticket\ Revenue}{84} * 100$$

Equation 1: Ordinary Passengers Travelling Distance

Equation 1 was generated using monthly revenue data obtained before the year 2011. However, for today, the formula is not sufficiently accurate to find the distance travelled by the passengers due to drastic increase in revenue after January 2012 as illustrated in Figure 1.

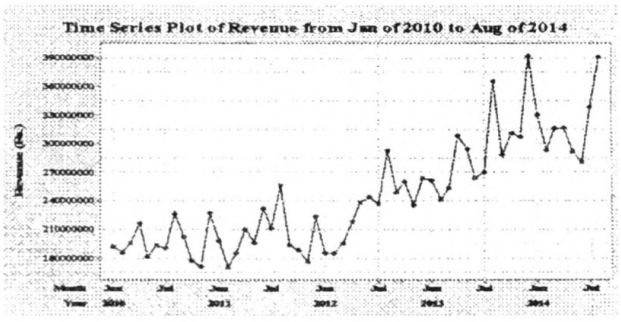

Figure 1: Time Series Plot of Monthly Revenue from Ordinary Tickets of Railway

According to Figure1, the monthly revenue from ordinary tickets during the period of January 2010 to January 2012 has seasonal variation but no trend. After this period it can be seen that the series has an upward trend together with the seasonal variation in the revenue.

Though the passengers' travelled distance is one of the important performance indicators, currently it is not used to measure their performances as there is no correct way to calculate the distance travelled by the passengers. Therefore, the objective of the research is to construct a new formula to calculate total distance travelled by the passengers per month per station.

METHODOLOGY

Ordinary passengers can travel by 1st, 2nd or economy class. For the present study, passengers travelled by economy class were taken into consideration, since this class is the most popular and profitable among the three classes. To reach the objective of this study, initially the present railway system and its operations were considered. Also, the patterns of numbers of tickets issued from each station and the monthly total revenue were studied separately. Since there were variations in monthly average revenue and the number of tickets issued among zones, which are defined in Table 1, a single formula to predict passengers' travel distance was inappropriate. Therefore this study proposed five equations to five zones each measures passengers' travelled distance corresponding to each zone.

Based on variations in monthly revenue among zones and railway stations, Revenue per passenger per month (RPP) was identified as an appropriate index to divide 307 railway stations into 9 homogeneous groups. Stratified sampling technique was applied to select a representative sample assuming each RPP group as stratum. Then 45 stations were selected using simple random sampling. The collected data was used to calculate the percentage contribution of revenue received from each zone to the total monthly revenue for particular RPP group. Also the percentage contribution of tickets issued from each zone and to total monthly tickets issued for particular RPP group were calculated. More over these constants were utilized to construct formula for each zone.

Further, mean absolute error was calculated to measure the accuracy of new formula and existing formula in predicting total distance travelled by passengers. In addition to that, the error percentages from both formulas were compared in order to show the adequacy of the new formula in predicting total distance travelled by the passengers.

Table 1 shows how CGR calculates economy class passenger fare based on the distance. This divided passenger travel distance in to five zones namely zone_1 to zone_5.

Table 1: Economy Class Passenger Fare Corresponding to each Zone

Name of the Zone	Distance Corresponding to each Zone	Cost per Passenger per Kilometer	Maximum Cost per Passenger	Cumulative Cost per Passenger	Actual Maximum Cost for a Passenger
Zone_1	From 0km to 10km	1.10	11	11	10
Zone_2	From 11km to 50km	1.00	40	51	50
Zone_3	From 51km to 100km	0.85	42.5	93.5	95
Zone_4	From 101km to 200km	0.65	65	158.5	160
Zone_5	Greater than 200km	0.50	Greater than 65	Greater than 158.5	Greater than 160

DATA COLLECTION AND ANALYSIS

Secondary data from January 2013 to September 2014 were collected from the monthly revenue report. The collected data were divided into two subsets for the purpose of training and testing. The training data were used to construct formulas and the testing data were used to check the validity of the model. Data collected from January 2013 to August 2014 were used to calculate the RPP, and months of June and September in year 2014 were used to calculate the percentage contributions of each zone to total revenue and number of tickets issued. To test the accuracy of the fitted and existing formula the secondary data from December 2013 to February 2014 were considered.

The following Figure 2 shows the percentage contribution from each class to the average ordinary tickets issued per month.

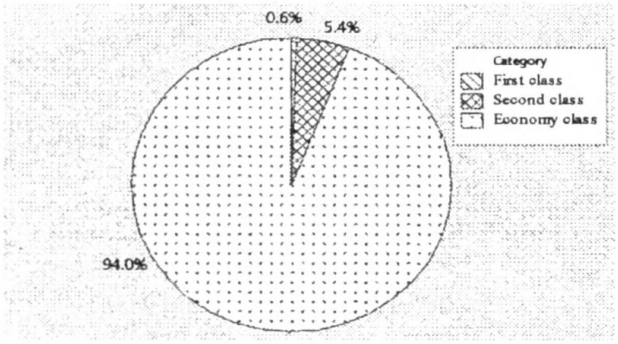

Figure 2: Monthly Average Percentage of Issued Tickets from each Class

The results reveal that the highest percentage (94%) of tickets has been issued for the economy class. Average tickets issued for other two classes are comparatively small. Therefore this study was carried out only for tickets issued under economy class as performance at CGR mainly depend on revenue received from this class.

The following Figure 3 demonstrates the monthly average revenue received from two different stations Dehiwala and Batticalow during the period of study.

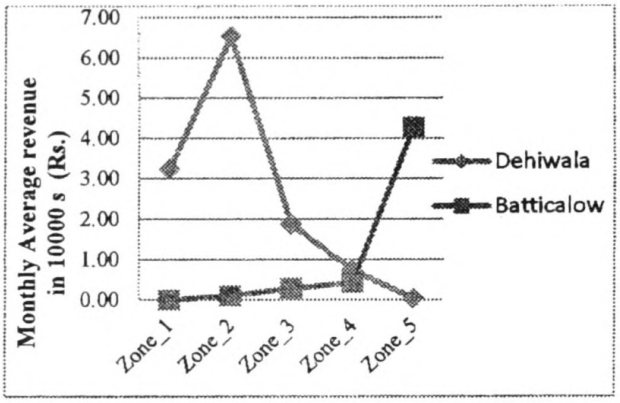

Figure 3: Variations in Revenue against Zones

Figure 3 illustrates the distributions of the monthly average revenue in each of the two stations. In Dehiwala station, the average revenue decrease when the zone number increase and in Batticaloa it increase. This leads to realize that the distribution of monthly average revenues were differ among stations.

Revenue per passenger per month was calculated for each 307 stations and these were grouped into nine as illustrated in the following Figure 4.

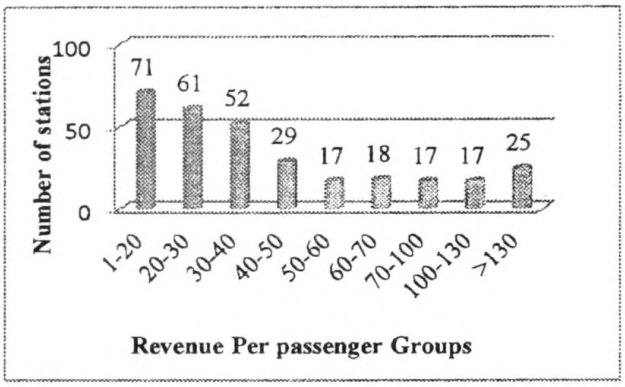

Figure 4: The Distribution of Stations against RPP Groups

According to Figure 4, there are 71 stations having RPP per month less than 20 rupees. For the 2nd and the 3rd group the RPP varies between 20-30 and 30-40 rupees respectively. Only 25 stations received more than 130 rupees as RPP per month.

The distribution of monthly average revenue and issued tickets against zones for the stations belongs to RPP group 1-20 are shown in following Figure 5 and 6 respectively.

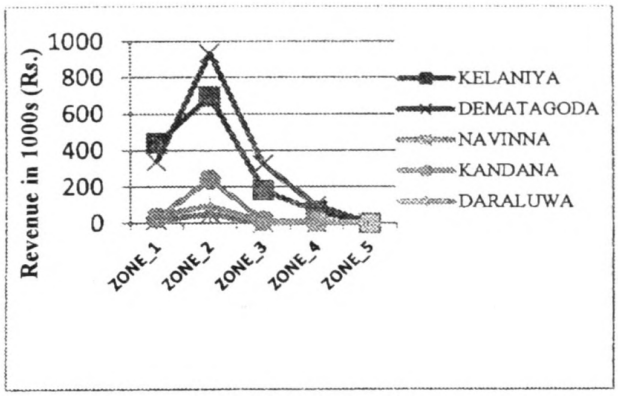

Figure 5: Distribution of Monthly Average Revenue against Zone for RPP 1-20 Group

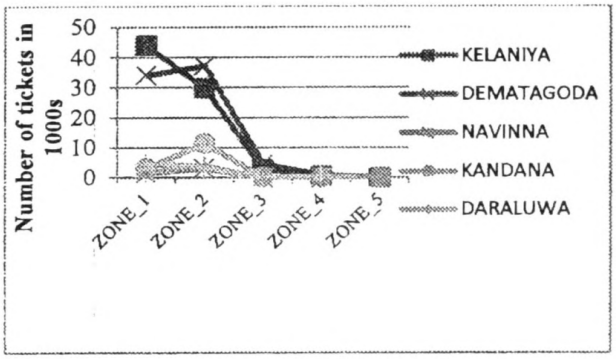

Figure 6: Distribution of Monthly Average Issued Tickets against Zone for RPP 1-20 Group

Figures 5 and 6 show that the stations belong to RPP group 1-20 follow similar patterns in their distributions of monthly revenue and tickets issued against zones. Moreover, the results for remaining RPP groups followed the similar patterns within each group.

The calculated percentage contributions of issued tickets for each zone to the total tickets issued per month under particular RPP group were summarized in Table 2.

The calculated percentage contributions of revenue received for each zone to total monthly average revenue under particular RPP group were given in below Table 3.

Table 2: Tickets Percentages Corresponding to Revenue per Passenger Groups and Zone

Group	Zone1(%)	Zone2(%)	Zone3(%)	Zone4(%)	Zone5(%)
1-20	58.87	37.23	3.14	0.73	0.02
10-20	26.23	67.56	3.81	2.19	0.22
30-40	25.93	62.58	5.72	5.37	0.39
40-50	23.98	42.40	10.61	20.94	2.07
50-60	29.93	25.25	15.88	22.60	6.34
60-70	15.57	25.62	53.27	4.57	0.96
70-100	5.93	28.64	25.37	34.52	5.54
100-130	8.20	25.47	6.40	48.80	11.13
>130	7.34	18.94	13.36	12.44	47.92

Table 3: Revenue Percentages Corresponding to Revenue per Passenger Group and Zone

Group	Zone1(%)	Zone2(%)	Zone3(%)	Zone4(%)	Zone5(%)
1-20	33.31	49.67	11.92	4.89	0.21
10-20	11.20	63.64	11.25	12.18	1.74
30-40	9.14	52.22	13.69	22.39	2.57
40-50	4.97	22.33	17.59	47.20	7.91
50-60	4.87	12.74	17.53	43.14	21.72
60-70	2.69	13.36	71.47	9.54	2.95
70-100	0.77	11.01	26.55	47.42	14.25
100-130	0.84	7.69	4.95	64.10	22.41
>130	0.56	3.70	7.50	12.28	75.96

According to Table 2, the tickets issued for zone_1 under RPP group 1-20 provides 58.87% of contribution to the total tickets issued per month. Similarly 37.23%, 3.14%, 0.73% and 0.02% of contribution were from zone 2, 3, 4, and 5 respectively.

Table 3 indicates that monthly revenue received from zone_1 under RPP group 1-20 provides 33%of contribution to the total revenue received per month. Also approximately 50%, 12%, 5%and 0.2% of contributions were from zone 2, 3, 4, and 5 respectively. After identifying the RPP group for particular station, the constant terms presented in both Tables2 and 3 were selected appropriately to calculate travelled distance by passengers.

RESULT AND DISCUSSION

The following Equations 2 to 6 were identified as appropriate formulas to calculate the distance travelled by passengers in Kilometers for zones 1 to 5 respectively.

The summation of the results obtained from each formula yield the total distance travelled by passengers per month per station.

$$\text{Distance from Zone\_1} = \frac{11 * \text{Number of issued tickets for zone\_1}}{2}$$

Equation 2: Distance from zone 1

$$\text{Distance from Zone\_2} = \frac{\text{Revenue from Zone\_2} - 11 * \text{Total number of issued tickets for zone\_2}}{1.00}$$

Equation 3: Distance from zone 2

$$\text{Distance from Zone\_3} = \frac{\text{Revenue from Zone\_3} - 50 * \text{Total number of issued tickets for zone\_3}}{0.85}$$

Equation 4: Distance from zone 3

$$\text{Distance from Zone\_4} = \frac{\text{Revenue from Zone\_4} - 95 * \text{Number of issued tickets for zone\_4}}{0.65}$$

Equation 5: Distance from zone 4

$$\text{Distance from Zone\_5} = \frac{\text{Revenue from Zone\_5} - 160 * \text{Number of issued tickets for zone\_5}}{0.5}$$

Equation 6: Distance from zone 5

Where, Revenue from zone_i= total revenue per month per station * percentage contribution (given in Table 3) corresponding to zone_i and RPP group that station belong to.

Number of issued tickets for zone _i=total ticket issued per month per station * percentage contribution (given in Table 2) corresponding to zone_i and RPP group that station belong to; i=1, 2, 3, 4 and 5.

The residual analysis revealed that the mean absolute percentage error was 19.64 % in predicting the distanced travelled by passengers for the existing formula, while it was 11% for the new formula introduced here. This leads to conclude that the error percentage in calculating distance was comparatively low in the equation proposed by this study.

CONCLUSION

Every company expects high profit from its products and services. There are performance indicators to show how well they are doing in their business. To measure the performance of CGR, they have considered several indicators.

Passengers' traveling distance is one of the key indicators that they currently use to measure their performance. The main objective of this research was to construct a formula to calculate passengers' travel distance for any given railway station, since the existing formula for this purpose was not performing properly due to drastic trends in revenue, occurred recently.

Details of tickets issued for economy class were considered in this calculation as it is the most popular and profitable among these three classes.

The formula introduced here predicts passengers' travel distance more accurately than the exiting formula. Therefore, this formula could be used to calculate the passengers' travelling distance and thereby they can estimate the cost they incur for a passenger per kilometer. This helps CGR to measure their performance and further they can take necessary steps to maintain their level of performance.

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