# Identification of Seasonal Effects through Ratio to Moving Average Method for the Number of Train Passengers and Income of South Central Railway Zone

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***Abstract*—** *Earlier [9,10 and 11] the authors worked on Trend effects and Seasonal effects on number of passengers and income of South Central Railway Zone for the data collected from 2009 to 2017. While calculating trend values [9] we have used different linear and non-linear models like Straight line, Parabola, Exponential and Power curve models. Similarly to determine Seasonal effects [10] we have used Simple Averages Method and Ratio to Trend Method [11]. Now we proceed to determine Seasonal effects through an improved method over Simple Averages and Ratio to Trend Method namely '**Ratio to Moving Average Method'**. Conclusions are drawn based on the results obtained.*

**Keywords—** *Ratio to Moving Average Method, Simple Averages Method, Ratio to Trend Method, Seasonal effects, Trend effects.*

## I. INTRODUCTION

Now a days **Railways** occupy a predominant role in transporting people/goods from one place to another place. Even though the system is introduced by the British Government prior to Independence, more and more advancements and changes are introduced into the Railway system by Indian Government who came after independence, such as introduction of automization in signaling, introduction of online reservation system, providing net-work facilities in the train and so on.

For example determination of current positions of various trains by using e-applications, tatkal, premium facilities, various concessions for women and senior citizen passengers etc are some of them, thus making the train journey more **comfortable, safer and reliable.** Because of these improved facilities Railways are earning more and more income, attracting more and more passengers by providing more and more facilities. This motivated us to do some work on number of Railway passengers and income for future guidance and future plans for improving existing facilities. In order to do that, we have collected month-wise data of number of passengers and corresponding income of the period from **2009 to 2017** of South Central Railway Zone.

In paper [9] we have determined trend values through linear and non-linear models like Straight line, Parabola, Exponential and Power curve and identified **'Parabola' trend** model is the best model. Further in second paper [10] our concentration is diverted towards the determination of Seasonal effects on the variables under consideration. There we used Simple Averages Method. Similarly in third paper [11] our concentration is diverted towards the determination of Seasonal effects on the variables under consideration where we used **Ratio to Trend Method**.

In the present paper an improved method namely **'Ratio to Moving Average Method'** is applied and determined the Seasonal Indices for data of number **of Train Passengers and Income** of South Central Railway Zone. Now we proceed to explain some preliminaries of the Ratio to Moving Average Method to obtain the results of **Seasonal Indices** in the following section.

## II. METHODOLOGY

Earlier, it is mentioned that [9, 10 and 11] Seasonal Indices can be calculated by using the following four methods.

(i) Method of simple averages
(ii) Ratio to trend method
(iii) Ratio to moving average method
(iv) Link relative method.

Determination of Seasonal Indices through method of Simple Averages [10] has a major drawback or disadvantage that this method is more depending on extreme values giving more weightage to extreme values which are not primary to Seasonal variations. This can be explained as follows:

**Seasonal effects** are those effects whose period is less than one year and should occur in equal intervals.
For example: Demand of trains in summer vacation, Dussehra, Ramzan, Christmas month, Brahmotsavam at Tirumala Tirupati Devasthanams (TTD) etc can be considered as Seasonal effects.

During the events like Jathras, Kumbamela and Pushkaras or during any special occasions, number of train passengers and income increase abruptly. In those situations Railway administration has to increase number of trains (in the form of special trains) or adding extra bogies in existing trains. It is required to meet the increasing demand on those special occasions. These effects are not due to **Seasonal effects.** These are called **cyclical effects.**

Ratio to moving average method is an improvement over the simple averages method and Ratio to Trend Method and is based on the assumption that seasonal variation for any given month is constant factor of the trend. As pointed out earlier moving average method eliminates periodic movements, if they exist. (Period of moving average is equal to the period of the oscillatory movements and sought to be eliminated). Thus for a monthly data, a 12 month moving average should completely eliminate the seasonal movements if they are of constant pattern and intensity. The method of getting seasonal indices by ratio to moving average involves the following steps:

**Step-I:** Enter the data in MS-Excel sheet.

**Step-II:** Calculate 4 period totals and averages by taking first four values.

**Step-III:** Next by dropping the first value again take four values find the total and average. Next by dropping the second value take 4 values, find the total and average and so on.

**Step-IV:** Again take 2 period moving averages to get centered averages.

**Step V**: Using multiplicative model calculate $(U_t/M.A)x100$ values.

**Step VI:** Find the average of these values which are quarterly indices (Q.I), the sum of Q.I=400. If not use correction factor $K_1$=(400/sum of Q.I) and multiply Q.I with $K_1$ to get adjusted Q.I.

**Step VII:** If we use additive model we follow the same procedure up to step IV. Calculate $(U_t - M.A)$ values. Find the average of these values which are Q.I. The sum of Q.I=0. If not use correction factor $K_2$= (1/4) x (sum of Q.I) and subtract Q.I with $K_2$ to get adjusted Q.I.

**Merits and Demerits:** Of all the methods of measuring seasonal variations, the ratio to the moving average method is the most satisfactory, flexible and widely used method. These indices do not fluctuate so much as the indices by the ratio to trend method.

This method does not completely utilize the data, e.g., in the case of 12-month moving average seasonal indices cannot be obtained for the first 6-months and for the last 6-months. [1, 2, 3, 4, 5, 6, 7 and 8]

## III. DATA AND CALCULATIONS (QUARTER-WISE)

(a) **: For no. of passengers**

**Table: 3.1 Ratio to Moving Average Method for No.of Passengers**

| Years | Quarters | No. of Passengers ($U_t$) | Quarterly Moving Totals | Quarterly Moving Averages | Moving Average (M.A) | (Multiplicative Model) ($U_t$/ M.A) * 100 | (Additive Model) $U_t$ - M.A |
|---|---|---|---|---|---|---|---|
| 2009 | Q1 | 6180011 | | | | | |
| | Q2 | 6802061 | | | | | |
| | Q3 | 7042493 | 27354436 | 6838609 | 7032019.75 | 100.1489 | 10473.25 |
| | Q4 | 7329871 | 28901722 | 7225430.5 | 7351890.63 | 99.70049 | -22019.63 |
| 2010 | Q1 | 7727297 | 29913403 | 7478350.75 | 7662415.75 | 100.8467 | 64881.25 |
| | Q2 | 7813742 | 31385923 | 7846480.75 | 7988279.5 | 97.81508 | -174537.5 |
| | Q3 | 8515013 | 32520313 | 8130078.25 | 8242501.75 | 103.3062 | 272511.25 |
| | Q4 | 8464261 | 33419701 | 8354925.25 | 8424630.75 | 100.4704 | 39630.25 |
| 2011 | Q1 | 8626685 | 33977345 | 8494336.25 | 8575269 | 100.5996 | 51416 |
| | Q2 | 8371386 | 34624807 | 8656201.75 | 8721463.63 | 95.98602 | -350077.6 |
| | Q3 | 9162475 | 35146902 | 8786725.5 | 8895776 | 102.998 | 266699 |
| | Q4 | 8986356 | 36019306 | 9004826.5 | 9077223.75 | 98.99895 | -90867.75 |
| 2012 | Q1 | 9499089 | 36598484 | 9149621 | 9713180.13 | 97.79587 | -214091.1 |
| | Q2 | 8950564 | 41106957 | 10276739.3 | 10278015 | 87.08456 | -1327451 |
| | Q3 | 13670948 | 41117163 | 10279290.8 | 10305259.6 | 132.6599 | 3365688.4 |
| | Q4 | 8996562 | 41324914 | 10331228.5 | 10231689.6 | 87.92841 | -1235128 |
| 2013 | Q1 | 9706840 | 40528603 | 10132150.8 | 9704537.63 | 100.0237 | 2302.375 |
| | Q2 | 8154253 | 37107698 | 9276924.5 | 9417122.13 | 86.58965 | -1262869 |
| | Q3 | 10250043 | 38229279 | 9557319.75 | 9620315.63 | 106.5458 | 629727.38 |
| | Q4 | 10118143 | 38733246 | 9683311.5 | 9949854.13 | 101.6914 | 168288.88 |
| 2014 | Q1 | 10210807 | 40865587 | 10216396.8 | 10224897.6 | 99.86219 | -14090.63 |
| | Q2 | 10286594 | 40933594 | 10233398.5 | 10299237.4 | 99.87724 | -12643.38 |
| | Q3 | 10318050 | 41460305 | 10365076.3 | 10350649.6 | 99.68505 | -32599.63 |
| | Q4 | 10644854 | 41344892 | 10336223 | 10430736.1 | 102.0528 | 214117.88 |
| 2015 | Q1 | 10095394 | 42100997 | 10525249.3 | 10618679.5 | 95.07203 | -523285.5 |
| | Q2 | 11042699 | 42848439 | 10712109.8 | 10642668.8 | 103.7587 | 400030.25 |
| | Q3 | 11065492 | 42292911 | 10573227.8 | 10687103.6 | 103.5406 | 378388.38 |
| | Q4 | 10089326 | 43203918 | 10800979.5 | 10792591.3 | 93.48381 | -703265.3 |
| 2016 | Q1 | 11006401 | 43136812 | 10784203 | 10355212.9 | 106.2885 | 651188.13 |
| | Q2 | 10975593 | 39704891 | 9926222.75 | 10043824.8 | 109.277 | 931768.25 |
| | Q3 | 7633571 | 40645707 | 10161426.8 | 10266169.9 | 74.35656 | -2632599 |
| | Q4 | 11030142 | 41483652 | 10370913 | 10523199.1 | 104.8174 | 506942.88 |
| 2017 | Q1 | 11844346 | 42701941 | 10675485.3 | 11302461.6 | 104.7944 | 541884.38 |
| | Q2 | 12193882 | 47717752 | 11929438 | 11991206.5 | 101.6902 | 202675.5 |
| | Q3 | 12649382 | 48211900 | 12052975 | | | |
| | Q4 | 11524290 | | | | | |

**Table: 3.2 Calculation of Quarterly Indices from Trend eliminated values (Using Multiplicative Model)**

| Year | Q1 | Q2 | Q3 | Q4 | | |
|---|---|---|---|---|---|---|
| 2009 | | | 100.1489 | 99.70049 | | |
| 2010 | 100.8467 | 97.81508 | 103.3062 | 100.4704 | | |
| 2011 | 100.5996 | 95.98602 | 102.998 | 98.99895 | | |
| 2012 | 97.79587 | 87.08456 | 132.6599 | 87.92841 | | |
| 2013 | 100.0237 | 86.58965 | 106.5458 | 101.6914 | | |
| 2014 | 99.86219 | 99.87724 | 99.68505 | 102.0528 | | |
| 2015 | 95.07203 | 103.7587 | 103.5406 | 93.48381 | | |
| 2016 | 106.2885 | 109.277 | 74.35656 | 104.8174 | | |
| 2017 | 104.7944 | 101.6902 | | | | |
| Total | 805.28299 | 782.07845 | 823.241 | 789.1437 | | |
| Average (AM)(Q.I) | 100.660374 | 97.7598063 | 102.9051 | 98.64296 | 399.9683 | Total |
| Adjusted Q.I=(Q.I*$K_1$) | 100.668361 | 97.7675632 | 102.9133 | 98.65079 | 400 | Total |

$K_1$=400/399.9683

$K_1$=1.00007935

**Table: 3.3 Calculation of Quarterly Indices from Trend eliminated values (Using Additive Model)**

| Year | Q1 | Q2 | Q3 | Q4 | | |
|---|---|---|---|---|---|---|
| 2009 | | | 10473.25 | -22019.6 | | |
| 2010 | 64881.25 | -174538 | 272511.3 | 39630.25 | | |
| 2011 | 51416 | -350078 | 266699 | -90867.8 | | |
| 2012 | -214091 | -1327451 | 3365688 | -1235128 | | |
| 2013 | 2302.375 | -1262869 | 629727.4 | 168288.9 | | |
| 2014 | -14090.6 | -12643.4 | -32599.6 | 214117.9 | | |
| 2015 | -523286 | 400030.3 | 378388.4 | -703265 | | |
| 2016 | 651188.1 | 931768.3 | -2632599 | 506942.9 | | |
| 2017 | 541884.4 | 202675.5 | | | | |
| Total | 560204.53 | -1593105.3 | 2258288.8 | -1122300 | 103087.5 | Total |
| Average (AM) (Q.I) | 70025.566 | -199138.16 | 282286.09 | -140287.6 | 12885.8994 | Total |
| Adjusted Q.I=(Q.I-$K_2$) | 66804.091 | -202359.63 | 279064.62 | -143509.07 | 0 | Total |

$K_2$= 12885.89940/4

$K_2$= 3221.475

**(b) : For net income.**

**Table: 3.4 Ratio to Moving Average Method for Net Income**

| Years | Quarters | Net Income ($U_t$) | Quarterly Moving Totals | Quarterly Moving Averages | Moving Average (M.A)) | (Multiplicative Model) ($U_t$/ M.A)*100 | (Additive Model) $U_t$- M.A |
|---|---|---|---|---|---|---|---|
| 2009 | Q1 | 2009251857 | | | | | |
| | Q2 | 2113800080 | | | | | |
| | Q3 | 2193905287 | 8583730909 | 2145932727 | 2206752500 | 99.41782 | -12847213 |
| | Q4 | 2266773685 | 9070289089 | 2267572272 | 2303733546 | 98.39565 | -36959861 |
| 2010 | Q1 | 2495810037 | 9359579279 | 2339894820 | 2402149261 | 103.899 | 93660776 |
| | Q2 | 2403090270 | 9857614812 | 2464403703 | 2512601302 | 95.64153 | -1.1E+08 |
| | Q3 | 2691940820 | 1.0243E+10 | 2560798901 | 2599480413 | 103.5569 | 92460407 |
| | Q4 | 2652354478 | 1.0553E+10 | 2638161924 | 2659890335 | 99.71669 | -7535857 |
| 2011 | Q1 | 2805262129 | 1.0726E+10 | 2681618747 | 2592264431 | 108.2167 | 212997698 |
| | Q2 | 2576917559 | 1.0012E+10 | 2502910115 | 2521157739 | 102.2117 | 55759820 |
| | Q3 | 1977106294 | 1.0158E+10 | 2539405362 | 2574515357 | 76.79528 | -5.97E+08 |
| | Q4 | 2798335467 | 1.0439E+10 | 2609625351 | 2641074599 | 105.9544 | 157260869 |
| 2012 | Q1 | 3086142085 | 1.069E+10 | 2672523846 | 2839647833 | 108.6805 | 246494252 |
| | Q2 | 2828511537 | 1.2027E+10 | 3006771820 | 3015770542 | 93.79067 | -1.87E+08 |
| | Q3 | 3314098190 | 1.2099E+10 | 3024769264 | 3111990777 | 106.4945 | 202107413 |
| | Q4 | 2870325244 | 1.2797E+10 | 3199212290 | 3255008579 | 88.1818 | -3.85E+08 |
| 2013 | Q1 | 3783914189 | 1.3243E+10 | 3310804868 | 3404186269 | 111.1547 | 379727921 |
| | Q2 | 3274881847 | 1.399E+10 | 3497567670 | 3656292924 | 89.56837 | -3.81E+08 |
| | Q3 | 4061149398 | 1.526E+10 | 3815018178 | 3879866201 | 104.6724 | 181283197 |
| | Q4 | 4140127276 | 1.5779E+10 | 3944714225 | 4067290890 | 101.7908 | 72836387 |
| 2014 | Q1 | 4302698380 | 1.6759E+10 | 4189867554 | 4275802498 | 100.629 | 26895882 |
| | Q2 | 4255495161 | 1.7447E+10 | 4361737442 | 4456437553 | 95.49096 | -2.01E+08 |
| | Q3 | 4748628950 | 1.8205E+10 | 4551137664 | 4612962084 | 102.941 | 135666866 |
| | Q4 | 4897728165 | 1.8699E+10 | 4674786505 | 4783490449 | 102.3882 | 114237716 |
| 2015 | Q1 | 4797293742 | 1.9569E+10 | 4892194393 | 4946329071 | 96.98695 | -1.49E+08 |
| | Q2 | 5125126716 | 2.0002E+10 | 5000463748 | 4982245695 | 102.8678 | 142881021 |
| | Q3 | 5181706370 | 1.9856E+10 | 4964027641 | 5027386246 | 103.0696 | 154320124 |
| | Q4 | 4751983736 | 2.0363E+10 | 5090744851 | 5119270063 | 92.82542 | -3.67E+08 |
| 2016 | Q1 | 5304162582 | 2.0591E+10 | 5147795276 | 4959969253 | 106.9394 | 344193329 |
| | Q2 | 5353328414 | 1.9089E+10 | 4772143231 | 4840464790 | 110.5953 | 512863624 |
| | Q3 | 3679098192 | 1.9635E+10 | 4908786349 | 4972808693 | 73.98431 | -1.29E+09 |
| | Q4 | 5298556208 | 2.0147E+10 | 5036831037 | 5121758227 | 103.4519 | 176797981 |
| 2017 | Q1 | 5816341333 | 2.0827E+10 | 5206685418 | 5520034212 | 105.3678 | 296307121 |
| | Q2 | 6032745938 | 2.3334E+10 | 5833383006 | 5879385134 | 102.6084 | 153360804 |
| | Q3 | 6185888546 | 2.3702E+10 | 5925387261 | | | |
| | Q4 | 5666573228 | | | | | |

**Table: 3.5 Calculation of Quarterly Indices from Trend eliminated values (Using Multiplicative Model)**

| Year | Q1 | Q2 | Q3 | Q4 | | |
|---|---|---|---|---|---|---|
| 2009 | | | 99.41782 | 98.39565 | | |
| 2010 | 103.899 | 95.64153 | 103.5569 | 99.71669 | | |
| 2011 | 108.2167 | 102.2117 | 76.79528 | 105.9544 | | |
| 2012 | 108.6805 | 93.79067 | 106.4945 | 88.1818 | | |
| 2013 | 111.1547 | 89.56837 | 104.6724 | 101.7908 | | |
| 2014 | 100.629 | 95.49096 | 102.941 | 102.3882 | | |
| 2015 | 96.98695 | 102.8678 | 103.0696 | 92.82542 | | |
| 2016 | 106.9394 | 110.5953 | 73.98431 | 103.4519 | | |
| 2017 | 105.3678 | 102.6084 | | | | |
| Total | 841.8741 | 792.7747 | 770.9318 | 792.7049 | | |
| Average (AM) (Q.I) | 105.2343 | 99.09684 | 96.36648 | 99.08811 | 399.7857 | Total |
| Adjusted Q.I=(Q.I*$K_1$) | 105.2907 | 99.14997 | 96.41814 | 99.14123 | 400 | Total |

$K_1$=400/399.7857
$K_1$ =1.000536

**Table: 3.6 Calculation of Quarterly Indices from Trend eliminated values (Using Additive Model)**

| Year | Q1 | Q2 | Q3 | Q4 | | |
|---|---|---|---|---|---|---|
| 2009 | | | -12847213 | -36959861 | | |
| 2010 | 93660776 | 109511032 | 92460407 | -7535857 | | |
| 2011 | 212997698 | 55759820 | -597409063 | 157260869 | | |
| 2012 | 246494252 | -1.87E+08 | 202107413 | -3.85E+08 | | |
| 2013 | 379727921 | -3.81E+08 | 181283197 | 72836387 | | |
| 2014 | 26895882 | -2.01E+08 | 135666866 | 114237716 | | |
| 2015 | -1.49E+08 | 1.43E+08 | 154320124 | -3.67E+08 | | |
| 2016 | 344193329 | 5.13E+08 | -1.29E+09 | 176797981 | | |
| 2017 | 296307121 | 1.53E+08 | | | | |
| Total | 1451276979 | -13645763 | -1134418269 | -2.75E+08 | | |
| Average (AM) (Q.I) | 181409622 | -1705720.4 | -141802284 | -34420346 | 3481272 | Total |
| Adjusted Q.I=(Q.I-$K_2$) | 180539304.1 | -2576038.3 | -142672602 | -35290663.9 | 0 | Total |

$K_2$ = 3481271.60/4
$K_2$ = 870317.9

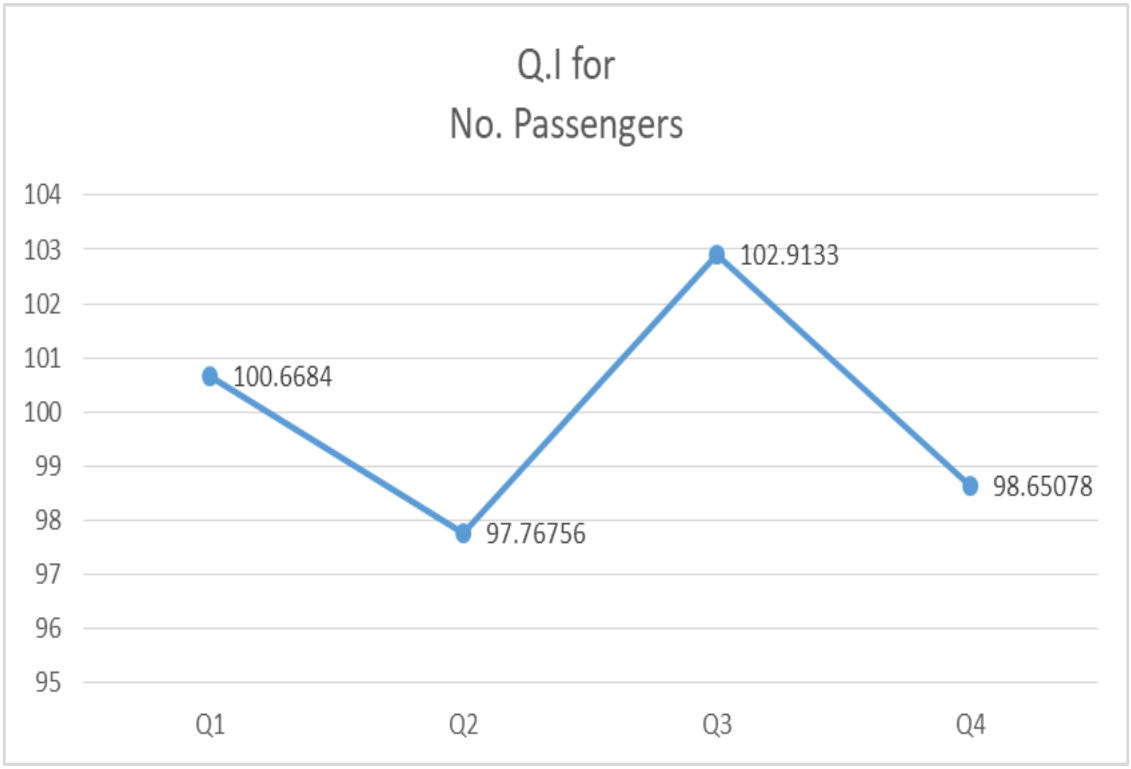


**Figure: 3.1 Quarterly Indices Graph for No. of Passengers from Trend eliminated values**

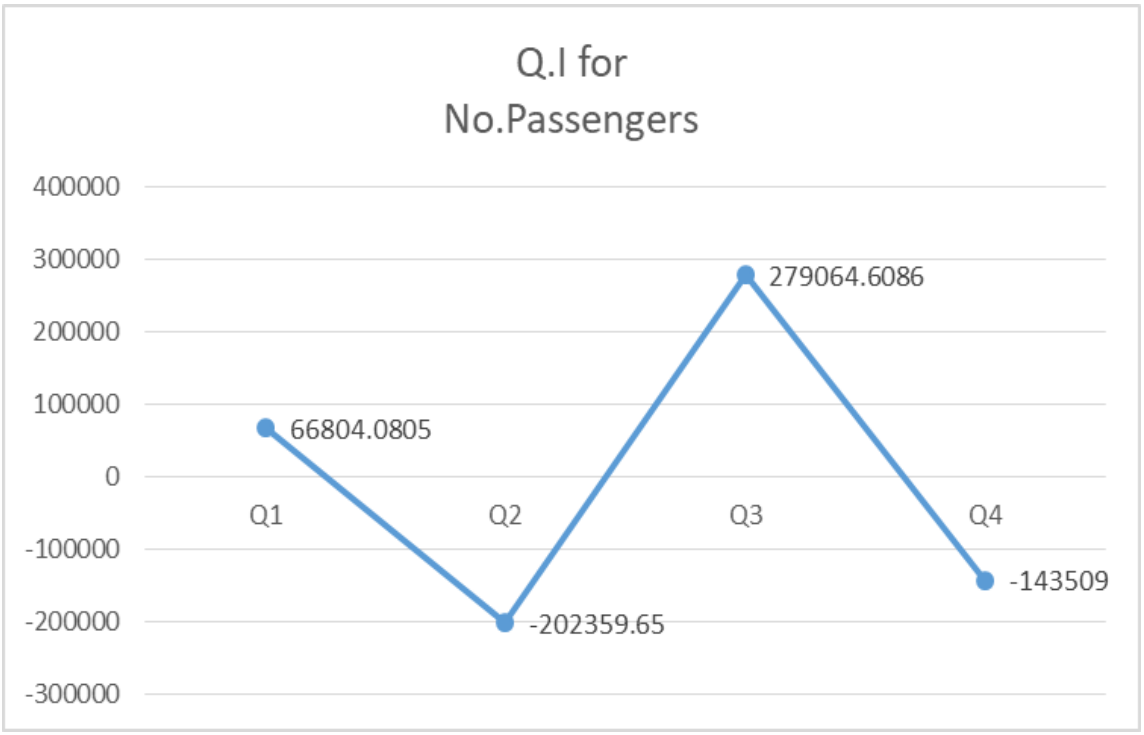


**Figure: 3.2 Quarterly Indices Graph for No. of Passengers from Trend eliminated values**

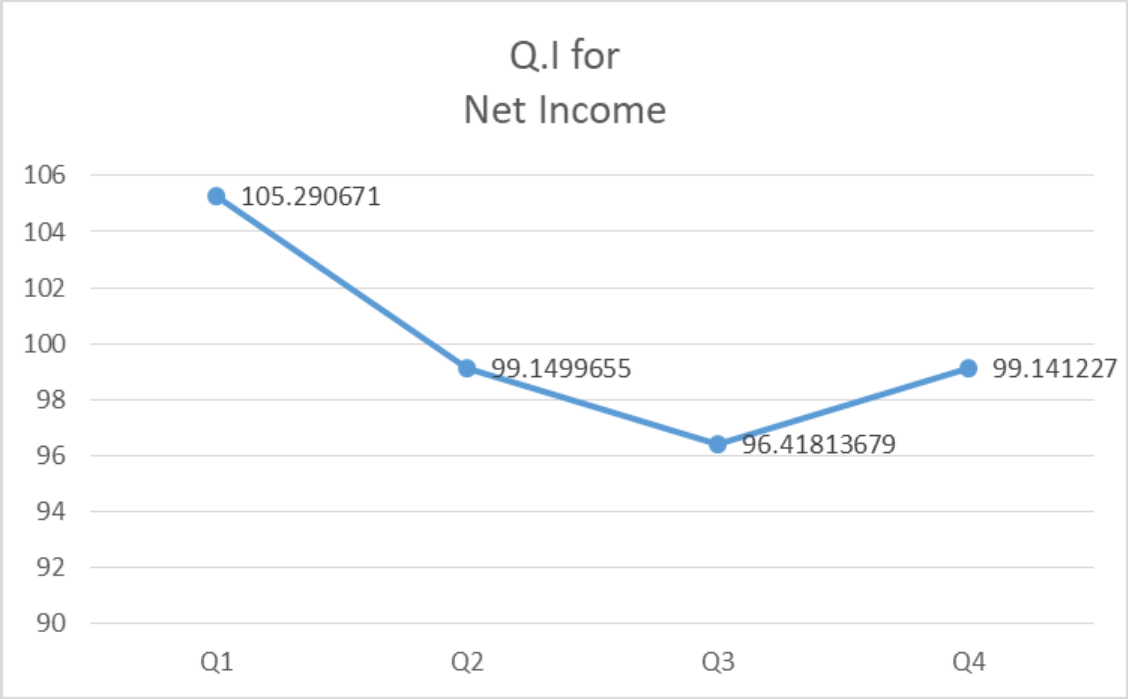


**Figure: 3.3 Quarterly Indices Graph for Net Income from Trend eliminated values**

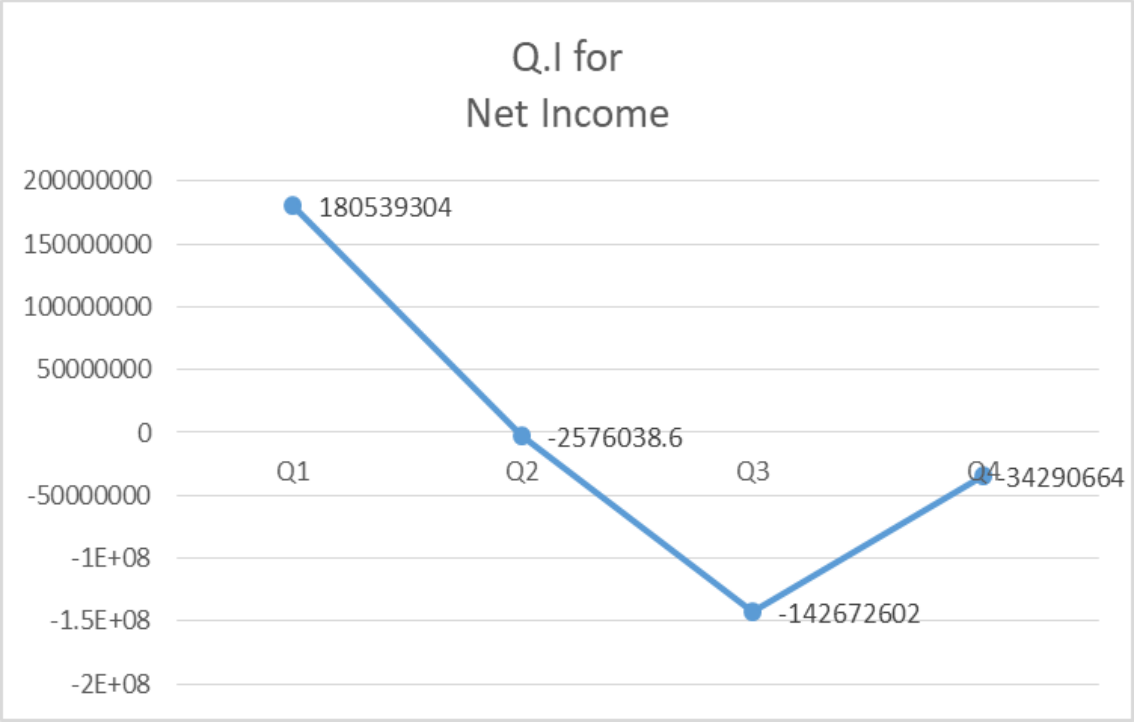


**Figure: 3.4 Quarterly Indices Graph for Net Income from Trend eliminated values**

## RESULTS AND DISCUSSION

By comparing critically Quarterly Indices for no. of passengers (3.1) and net income (3.3) along with their corresponding graphs after eliminating trend effects given in (3.2) and (3.4) the following conclusions can be drawn:

1. Seasonal Indices for Quarters clearly reveal that it is high in Quarter3 and low in Quarter2 for no. of passengers, both in multiplicative and additive models.
2. Income is high in Quarter1 and low in Quarter3, both in multiplicative and additive models.
3. This is because of the fact that in every year demand for trains is high in south-west monsoon and low in hot weather season (summer). It is observed through these graphs, the no. of passengers is high in south-west monsoon and low in hot weather season but the income is observed low in south-west monsoon and high income is observed in winter season. Astonishingly it is quite opposite in the cases of no. of passengers and income to railways.
4. This implies that in summer season more people are preferred to travel in A/C facility bogies which fetch more income to the railways than ordinary class fair.

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