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FORECASTING OF AIR TRAFFIC VOLUME OF INDIRA GANDHI INTERNATIONAL AIRPORT USING DECOMPOSITION TECHNIQUES

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Abstract: **Forecasting play very important role in construction of Airport, the study gave insight view of planning airport and design for further expansion. The study mainly focuses on the applicability of Traditional Time Series Analysis (Decomposition Technique). To facilitate the presentation, an empirical example is developed to forecast Air traffic volume of Delhi International Airport. In this study four air traffic indicator including total passenger traffic, total freight traffic and total air traffic movement were used for forecasting by three different decomposition technique.**

Index Terms **-** Passenger Traffic Volume, Forecasting, Decomposition, Time series.

I. INTRODUCTION

Air transport was an important part of economic growth, therefore developing statistical analysis and forecasting tool became important for long term strategy development for the strategic decision-maker. But there is no any proper forecasting technique and also forecast data may get affected by the certain factor which was not deal in this study. Example, in 2020 numerous airlines are suspending or drastically reducing their operation as the travel industry is experiencing record low demand due to COVID-19 spreads around the world. This will affect our data to reach the estimation. [1] Association of Private Airport Operation had taken statistical data from 2010 to 2017 of Delhi airport. And we have estimated our data up-to 2030. [2] Emrah ONDER, Sultan Kuzu Journal of Aeronautics and Space Technologies (2013) used classical time series forecasting technique such as smoothing (Linear moving average) and decomposition (cubic) method to forecast the air traffic volume of turkey airport.

1.1 Decomposition Methods

Decomposition methods are using for determining the secular trend, seasonal variation, conjuncture (cyclical variation) and random fluctuation (irregular variation) components in time series. It this study annual data was used from 2010 to 2017 and remaining data was estimated up to 2030. Therefore 3 important trend function including linear, quadratic and growth trends were used to forecast the four important airport parameter.

1.1.2. **Least Squares Method for Determining Trend**

The least-square method is one of the popular methods for determining trend. X is the time variable (year, month, etc.) in y' = f(x) function. If the sum of the time series variable (X) is identified as zero the estimation values of model parameters can be shown

$$\sum_{t=1}^{n} e_t^2 = \sum_{t=1}^{n} (y - y_t')^2 \quad \rightarrow min \tag{1}$$

1.1.3. Linear Trend Function The linear trend function is shown below:

$$y = a + bx + e_t \tag{2}$$

When the least-squares method is applied to the linear trend function, the equations below are obtained.

$$\sum_{t}^{n} e_t^2 = \sum_{t}^{n} (y_t - y_t') = \sum_{t=1}^{n} (y_t - a - bx)^2 \tag{3}$$

For determining the minimum of this function the first level derivatives should be done regarding a and b parameters.

$$\sum y(t) = na + b\sum x \quad (4)$$

$$\sum xy_t = a\sum x + b\sum x^2 \quad (5)$$

By solving these equations the parameters a and b can be found as follows:

$$a = \frac{\sum(y_t)}{n} \quad (6)$$

$$b = \frac{\sum xy_t}{\sum x^2} \quad (7)$$

1.2.1. Quadratic Trend Function

If the observed data has a carved figure (in quadratic trend function the mean of the data is increasing first than start decreasing or reverse) than quadratic trend function can be used.

$$y = a + bx + cx^2 + e_t \quad (8)$$

$$\sum_{t=1}^{n} e_t^2 = \sum_{t=1}^{n}(y_t - y_t')^2 \quad (9)$$

$$= \sum_{t=1}^{n}(y_t - a - bx - cx^2)^2 = 0 \quad (10)$$

First-order derivatives of the equation according to a, b and c parameters should be solved for writing the quadratic trend function with using least squares method. The equations below are the normal equations. Three unknown can be found by solving these three equations.

$$\sum y_t = na + b\sum x + c\sum x^3 \quad (11)$$

$$\sum xy_t = a\sum x + b\sum x^2 + c\sum x^3 \quad (12)$$

$$\sum x^2 y_t = a\sum x^2 + b\sum x^3 + c\sum x^4 \quad (13)$$

$$b = \frac{\sum xy_t}{\sum x^2} \quad (14)$$

1.3.1. Growth Trend Function

If the change of the y variable is nearly constant in time, growth trend function can be used for this kind. The growth trend function is shown below:

$$y_t = ab^x + e_t \quad (15)$$

$$\sum_{t=1}^{n} e_t^2 = \sum_{t=1}^{n}(logy_t - logy_t')^2 \quad (16)$$

$$= \sum_{t=1}^{n}(logy_t - loga - xlogb)^2 = 0 \quad (17)$$

$$\sum logy_t = nloga + logb\sum x \quad (18)$$

$$\sum xlogy_t = loga\sum x + logb\sum x^2 \quad (19)$$

$$loga = \frac{\sum logy_t}{n} \quad (20)$$

$$logb = \frac{\sum xlogy_t}{\sum x^2} \quad (21)$$

$$logy_t = loga + xlogb \quad (22)$$

2. FORECASTING

MATLAB code for decomposition technique as follows:

1. LINEAR TREND FUNCTION

Table 1.1: Domestic and International Passenger Traffic estimation (Linear Trend Function)

Year	Passenger Traffic (In Million)	Passenger Traffic (Domestic) (In Million)	Passenger Traffic (International) (In Million)
2010	30	20.7	9.3
2011	35.9	25.1	10.8
2012	34.4	22.8	11.6
2013	36.9	24.2	12.7
2014	41	27.5	13.5
2015	48.5	34.3	14.2
2016	57.7	42.2	15.5
2017	65.7	48.3	17.4
2018 (estimated)	65.4118	47.530	17.8818
2019 (estimated)	70.2289	51.29	18.9389
2020 (estimated)	76.1031	55.0500	19.9960
2021 (estimated)	80.9202	58.81	21.0531
2022 (estimated)	84.6802	62.57	22.1102
2023 (estimated)	89.4673	66.33	23.1673
2024 (estimated)	94.3144	70.0900	24.2244
2025 (estimated)	99.1315	73.85	25.2815
2026 (estimated)	103.9486	77.61	26.3386
2027 (estimated)	108.7657	81.37	27.3957
2028 (estimated)	113.5828	85.13	28.4528
2029 (estimated)	118.399	88.89	29.5099
2030 (estimated)	123.217	92.65	30.5670

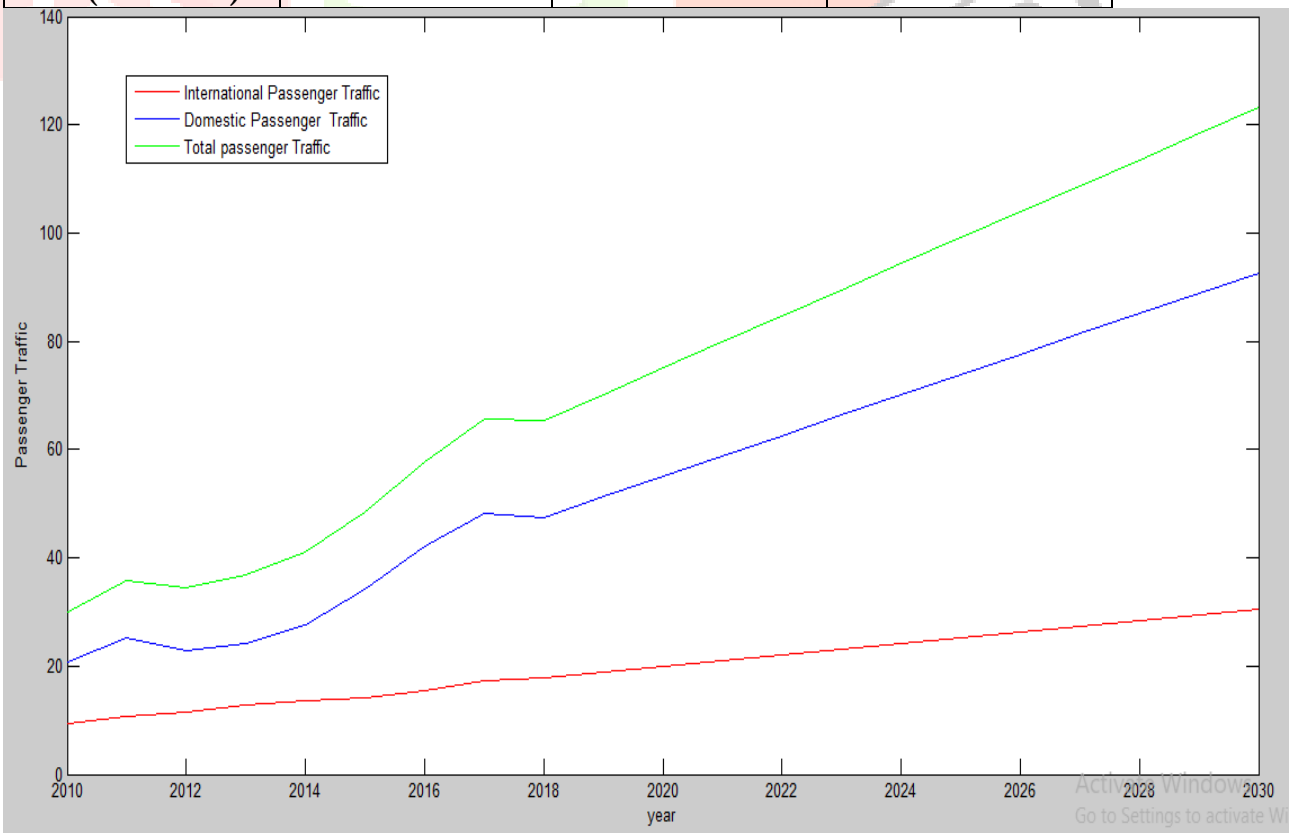

Figure 1.1 Domestic and International Passenger Traffic Estimation (Linear Trend function).

Table 1.2: Domestic and International Freight Traffic estimation (Linear Trend Function)

Year	Total Freight (In '000 tonnes)	Freight Traffic Domestic (In '000 tonnes)	Freight Traffic International (In '000 tonnes)
2010	600.0	209.1	390.9
2011	568.4	200.2	368.2
2012	546.3	188.2	358.1
2013	605.7	215.8	389.9
2014	696.5	271.8	424.8
2015	787.2	296.0	491.2
2016	857.4	298.4	559.1
2017	963.0	311.6	651.4
2018 (estimated)	960.2538	333.9538	626.3
2019 (estimated)	1017.357	352.8574	664.5
2020 (estimated)	1074.561	371.7610	702.8
2021 (estimated)	1131.665	390.6646	741.0
2022 (estimated)	1188.768	409.5682	779.2
2023 (estimated)	1247.972	428.4718	819.5
2024 (estimated)	1303.075	447.3754	855.7
2025 (estimated)	1360.279	466.2790	894.0
2026 (estimated)	1417.383	485.1826	932.2
2027 (estimated)	1474.486	504.0862	970.4
2028 (estimated)	1531.69	522.9898	1008.7
2029 (estimated)	1588.793	541.8934	1046.9
2030 (estimated)	1645.997	560.7970	1085.2

Figure 1.2. Domestic and International Freight Traffic Estimation (Linear Trend function).

Table 1.3: Domestic and International Air Traffic Movement estimation (Linear Trend Function)

Year	Total ATM's (in '000s)	Domestic (in '000s)	International (in '000s)
2010	255.6	180.8	74.8
2011	295.7	218.6	77.1
2012	280.7	200.3	80.4
2013	290.8	204.6	86.2
2014	300.9	215.5	85.8
2015	344.1	255.0	89.1
2016	397.8	297.5	100.3
2017	441.3	332.4	108.9
2018 (estimated)	433.5786	325.4464	108.2036
2019 (estimated)	457.5155	344.8595	112.7321
2020 (estimated)	481.4524	364.2726	117.2607
2021 (estimated)	505.3893	383.6857	121.7893
2022 (estimated)	529.3262	403.0988	126.3179
2023 (estimated)	553.2631	422.5119	130.8464
2024 (estimated)	577.2	441.9250	135.3750
2025 (estimated)	601.1369	461.3381	139.9036
2026 (estimated)	625.0738	480.7512	144.4321
2027 (estimated)	649.0107	500.1643	148.9607
2028 (estimated)	672.9476	519.5774	153.4893
2029 (estimated)	696.8875	538.9905	158.0179
2030 (estimated)	720.8214	558.4036	162.5494

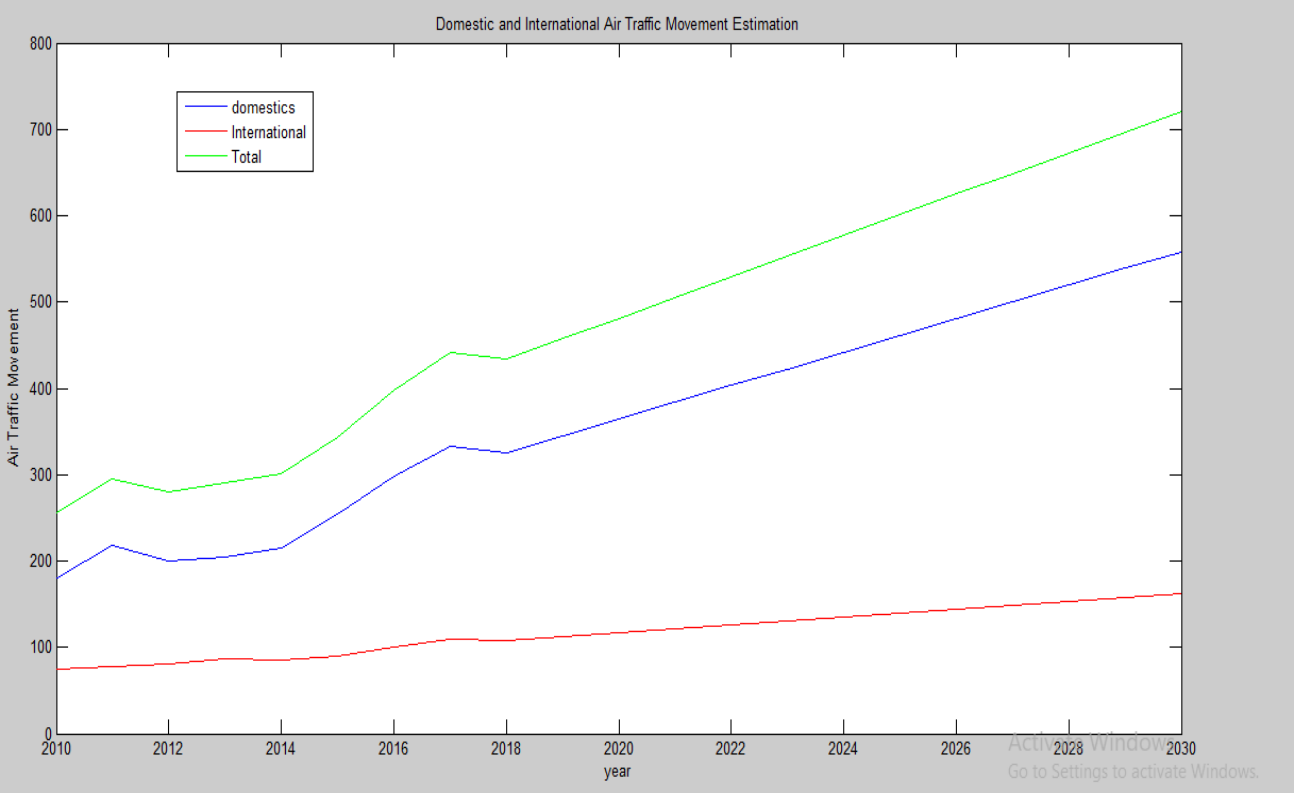

Figure 1.3. Domestic and International Air Traffic Estimation (Linear Trend function).

2. QUADRATIC TREND FUNCTION

Table 2.1: Domestic and International Passenger Traffic estimation (Quadratic Trend Function)

Year	Passenger Traffic (In Million)	Passenger Traffic (Domestic) (In Million)	Passenger Traffic (International) (In Million)
2010	30	20.7	9.3
2011	35.9	25.1	10.8
2012	34.4	22.8	11.6
2013	36.9	24.2	12.7
2014	41	27.5	13.5
2015	48.5	34.3	14.2
2016	57.7	42.2	15.5
2017	65.7	48.3	17.4
2018 (estimated)	76.6887	58.3518	18.31707
2019 (estimated)	88.9423	69.2923	19.65
2020 (estimated)	102.7123	81.6673	21.05
2021 (estimated)	117.09875	95.4768	22.5107
2022 (estimated)	134.7413	110.7208	24.0205
2023 (estimated)	152.9848	127.3884	25.5964
2024 (estimated)	172.7375	145.5125	27.2250
2025 (estimated)	193.9708	165.0601	28.9107
2026 (estimated)	216.6959	186.0423	30.6536
2027 (estimated)	242.7696	208.4589	34.3107
2028 (estimated)	268.5351	232.3101	36.2250
2029 (estimated)	295.7922	257.5958	38.1964
2030 (estimated)	324.2785	284.3161	39.9624

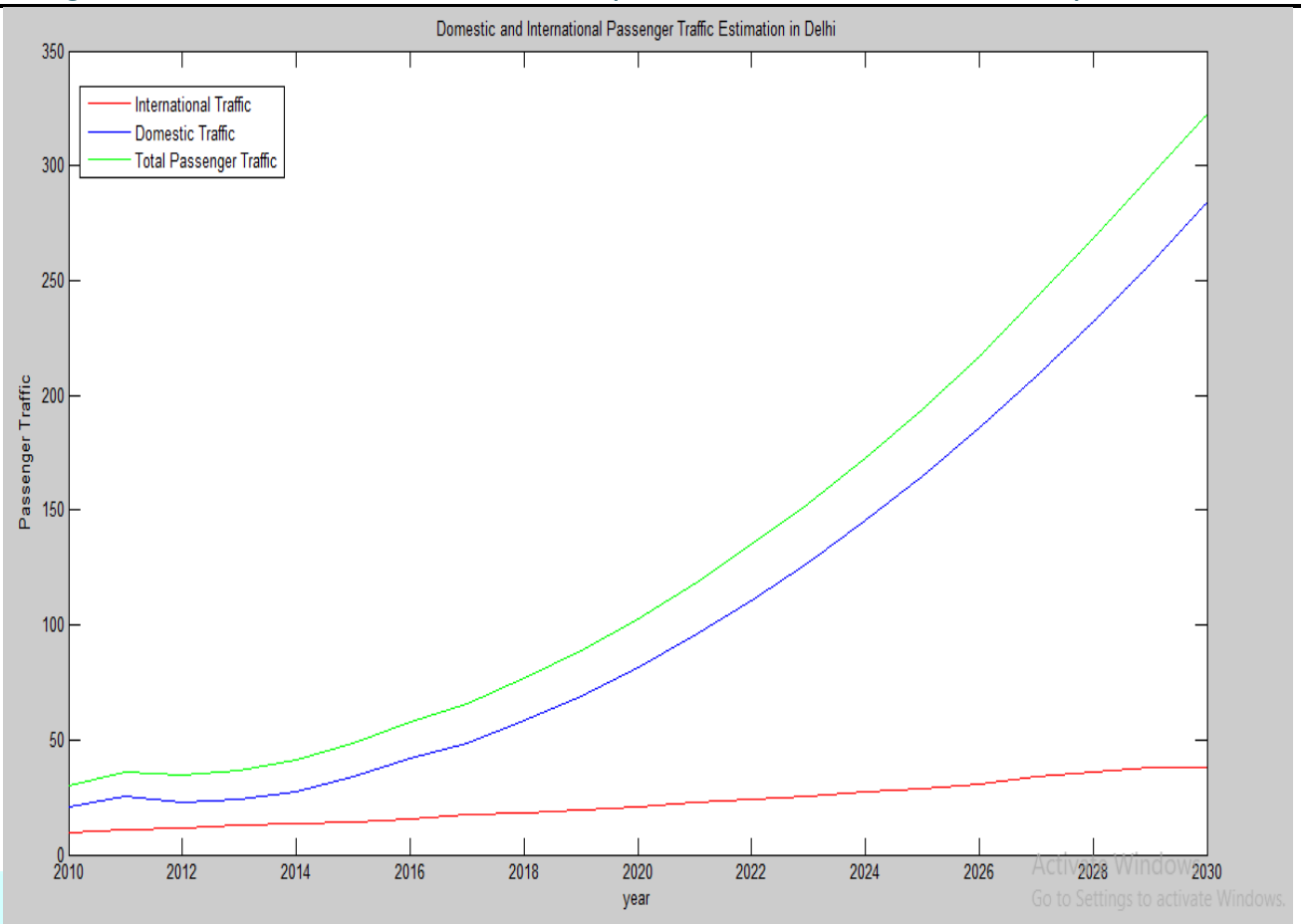

Figure 2.1 Domestic and International Passenger Traffic Estimation (Quadratic Trend function).

Table 2.2: Domestic and International Freight Traffic estimation (Quadratic Trend Function)

Year	Total Freight (In '000 tonnes)	Freight Traffic Domestic (In '000 tonnes)	Freight Traffic International (In '000 tonnes)
2010	600.0	209.1	390.9
2011	568.4	200.2	368.2
2012	546.3	188.2	358.1
2013	605.7	215.8	389.9
2014	696.5	271.8	424.8
2015	787.2	296.0	491.2
2016	857.4	298.4	559.1
2017	963.0	311.6	651.4
2018 (estimated)	980.3898	325.5898	654.8
2019 (estimated)	1125.837	356.5369	769.3
2020 (estimated)	1293.395	390.4948	902.9
2021 (estimated)	1483.064	427.4635	1055.6
2022 (estimated)	1694.743	467.4430	1227.3
2023 (estimated)	1928.533	510.433	1418.1
2024 (estimated)	2184.434	556.4344	1628.0
2025 (estimated)	2462.446	605.4463	1857.0
2026 (estimated)	2762.469	657.4690	2105.0
2027 (estimated)	3084.603	712.5025	2372.1
2028 (estimated)	3428.847	770.5468	2658.3
2029 (estimated)	3795.102	831.6019	2963.5
2030 (estimated)	4183.468	895.6678	3287.8

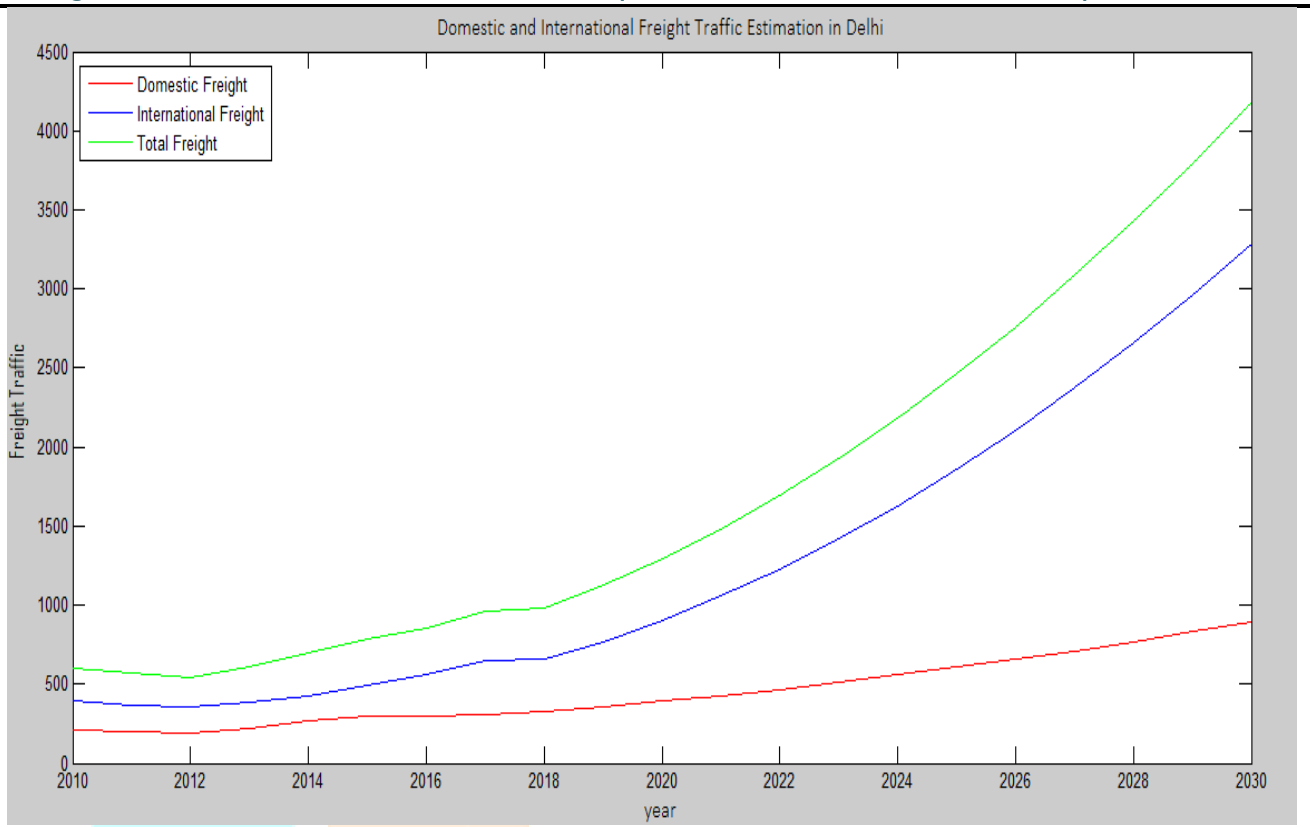

Figure 2.2 Domestic and International Freight Traffic Estimation (Quadratic Trend function)

Table 2.3: Domestic and International Air Traffic Movement estimation (Quadratic Trend Function)

Year	Total ATM's (in '000s)	Domestic (in '000s)	International (in '000s)
2010	255.6	180.8	74.8
2011	295.7	218.6	77.1
2012	280.7	200.3	80.4
2013	290.8	204.6	86.2
2014	300.9	215.5	85.8
2015	344.1	255.0	89.1
2016	397.8	297.5	100.3
2017	441.3	332.4	108.9
2018 (estimated)	499.6	382.8	116.6679
2019 (estimated)	567.5	440.4	126.8393
2020 (estimated)	644.2	505.7	138.1393
2021 (estimated)	729.7	578.6	150.5679
2022 (estimated)	827.40	659.2	164.1250
2023 (estimated)	927.1	747.4	178.8107
2024 (estimated)	1039.0	843.2	194.6250
2025 (estimated)	1159.7	946.7	211.5679
2026 (estimated)	1289.2	1057.9	229.6393
2027 (estimated)	1427.5	1176.7	248.8393
2028 (estimated)	1574.6	1303.1	269.1679
2029 (estimated)	1730.5	1437.2	290.6250
2030 (estimated)	1895.1	1578.9	313.2107

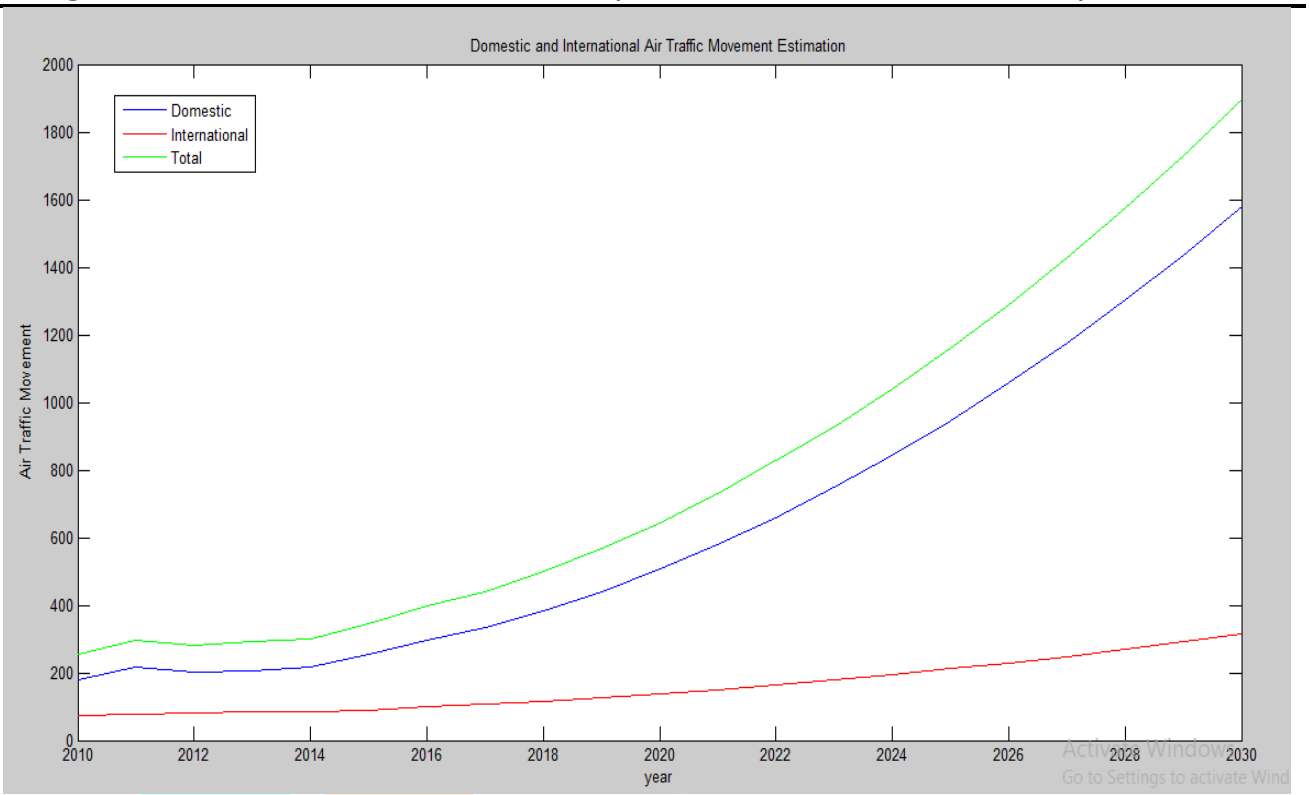

Figure 2.3 Domestic and International Air Traffic Movement Estimation (Quadratic Trend function)

3. GROWTH TREND FUNCTION

Table 3.1: Domestic and International Passenger Traffic estimation (Growth Trend Function)

Year	Passenger Traffic (In Million)	Passenger Traffic (Domestic) (In Million)	Passenger Traffic (International) (In Million)
2010	30	20.7	9.3
2011	35.9	25.1	10.8
2012	34.4	22.8	11.6
2013	36.9	24.2	12.7
2014	41	27.5	13.5
2015	48.5	34.3	14.2
2016	57.7	42.2	15.5
2017	65.7	48.3	17.4
2018 (estimated)	71.8279	53.2609	18.5670
2019 (estimated)	81.0204	60.8894	20.1310
2020 (estimated)	90.9871	69.1604	21.8267
2021 (estimated)	103.2431	79.5806	23.6625
2022 (estimated)	86.6075	60.9788	25.6287
2023 (estimated)	131.8296	104.0096	27.8200
2024 (estimated)	149.0701	118.9067	30.1634
2025 (estimated)	168.6399	135.9375	32.7024
2026 (estimated)	190.8669	155.4079	35.4590
2027 (estimated)	217.1123	177.6664	39.4459
2028 (estimated)	271.7975	230.1132	41.6843
2029 (estimated)	277.4004	232.2048	45.1956
2030 (estimated)	314.4657	265.4631	49.00261

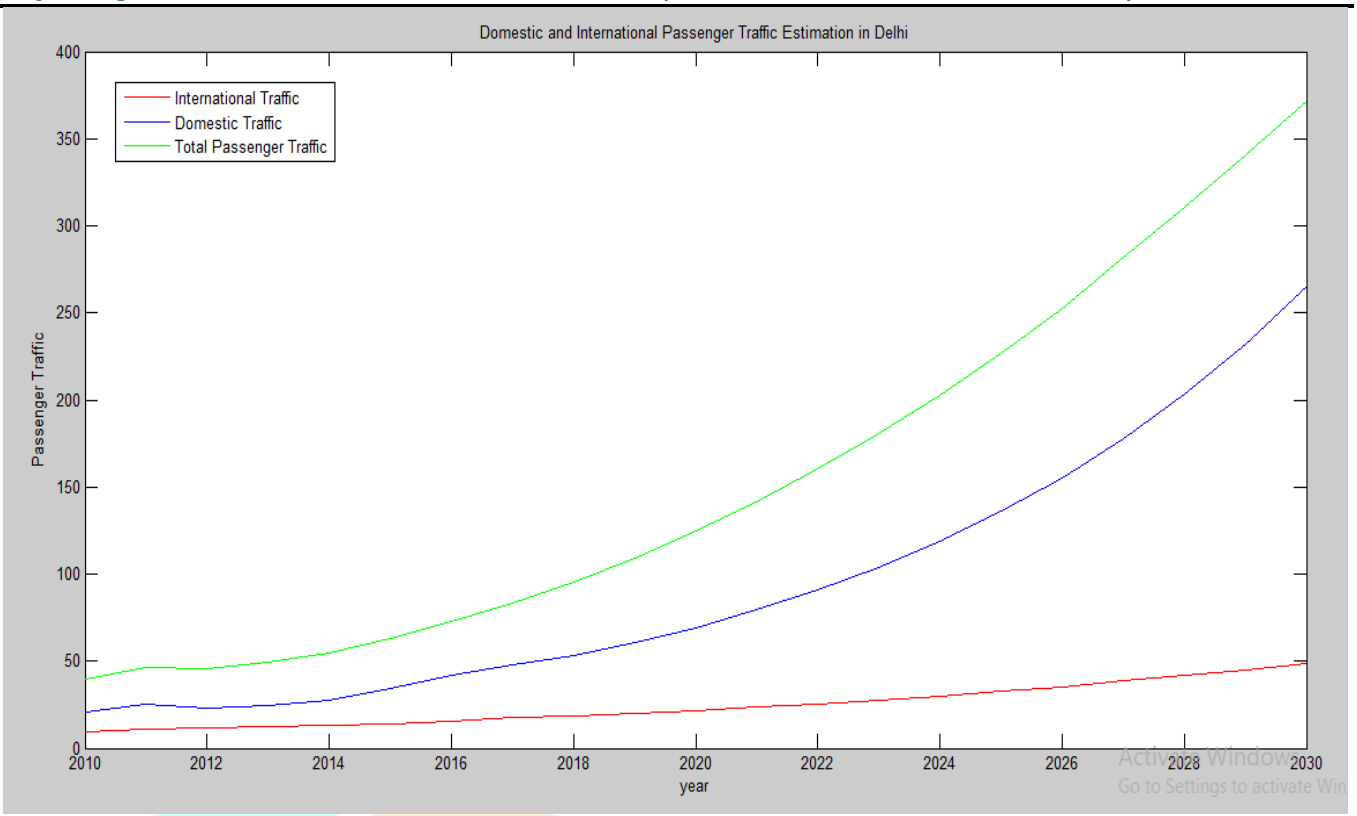

Figure 3. Domestic and International Passenger Traffic Estimation (Growth Trend function)

Table 3.2: Domestic and International Freight Traffic estimation (Growth Trend Function)

Year	Total Freight (In '000 tonnes)	Freight Traffic Domestic (In '000 tonnes)	Freight Traffic International (In '000 tonnes)
2010	600.0	209.1	390.9
2011	568.4	200.2	368.2
2012	546.3	188.2	358.1
2013	605.7	215.8	389.9
2014	696.5	271.8	424.8
2015	787.2	296.0	491.2
2016	857.4	298.4	559.1
2017	963.0	311.6	651.4
2018 (estimated)	931.5294	320.9294	610.6
2019 (estimated)	1015.556	346.6560	668.9
2020 (estimated)	1107.245	374.4450	732.8
2021 (estimated)	1207.262	404.4617	802.8
2022 (estimated)	1316.285	436.8845	879.4
2023 (estimated)	1435.307	471.9065	963.4
2024 (estimated)	1565.136	509.7360	1055.4
2025 (estimated)	1706.798	550.5980	1156.2
2026 (estimated)	1861.336	594.7356	1266.6
2027 (estimated)	2030.011	642.4114	1387.6
2028 (estimated)	2214.009	693.9090	1520.1
2029 (estimated)	2414.835	749.5349	1665.3
2030 (estimated)	2633.920	809.6199	1824.3

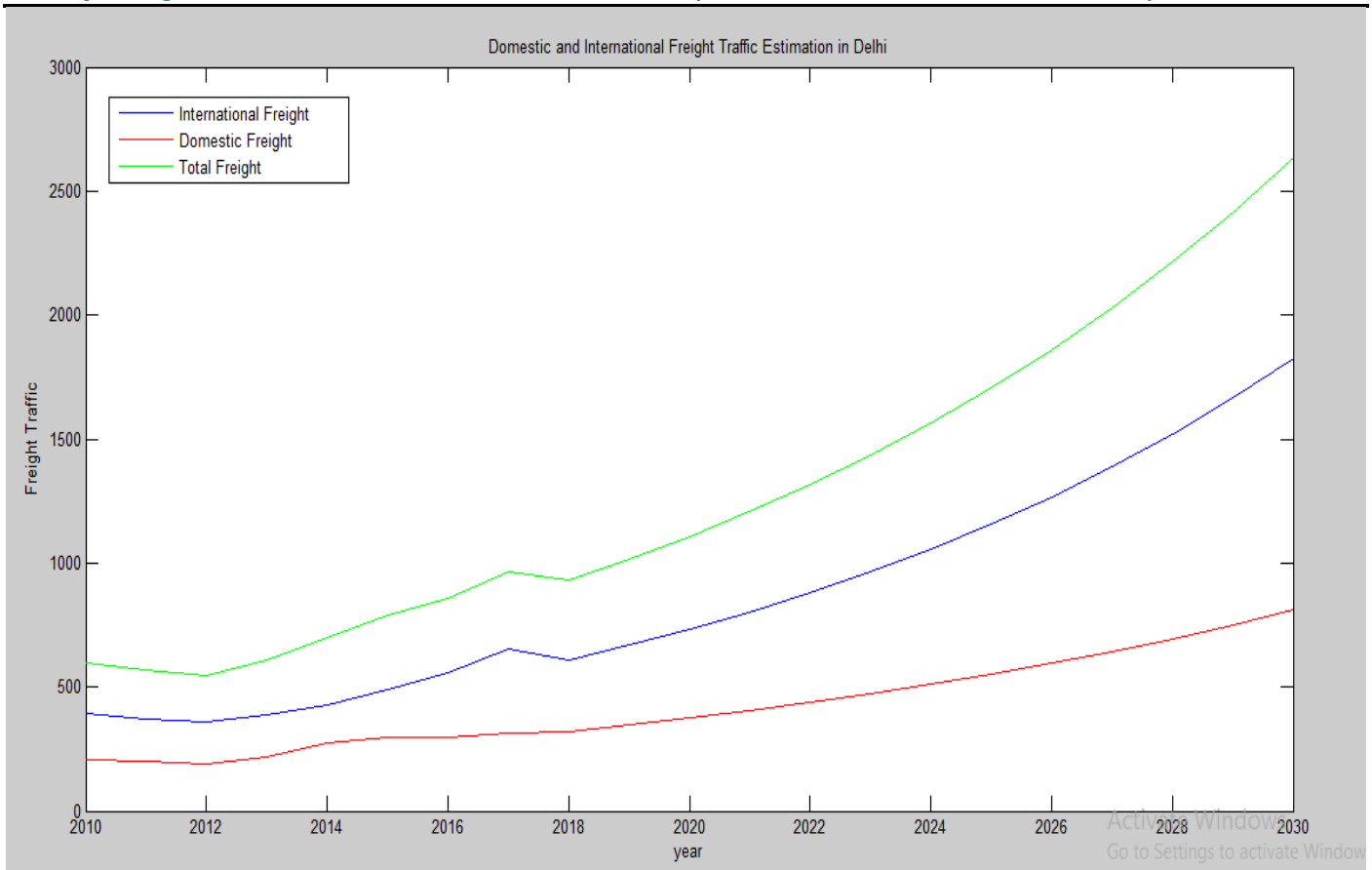

Figure 3.1 Domestic and International Freight Traffic Estimation (Growth Trend function)

Table 3.3: Domestic and International Air Traffic Movement estimation (Growth Trend Function)

Year	Total ATM's (in '000s)	Domestic (in '000s)	International (in '000s)
2010	255.6	180.8	74.8
2011	295.7	218.6	77.1
2012	280.7	200.3	80.4
2013	290.8	204.6	86.2
2014	300.9	215.5	85.8
2015	344.1	255.0	89.1
2016	397.8	297.5	100.3
2017	441.3	332.4	108.9
2018 (estimated)	454.1	344.550	110.5663
2019 (estimated)	490.6	375.7730	116.5647
2020 (estimated)	530.1	409.8194	122.8884
2021 (estimated)	572.7	446.9505	129.553
2022 (estimated)	618.8	487.4459	136.5838
2023 (estimated)	668.5	531.6103	143.9937
2024 (estimated)	722.3	579.7761	151.8055
2025 (estimated)	780.4	632.3059	160.0412
2026 (estimated)	843.2	689.5952	168.7236
2027 (estimated)	911.0	752.0750	177.8771
2028 (estimated)	984.3	820.2158	187.5271
2029 (estimated)	1063.4	894.5303	197.7007
2030 (estimated)	1149.0	975.5780	208.4262

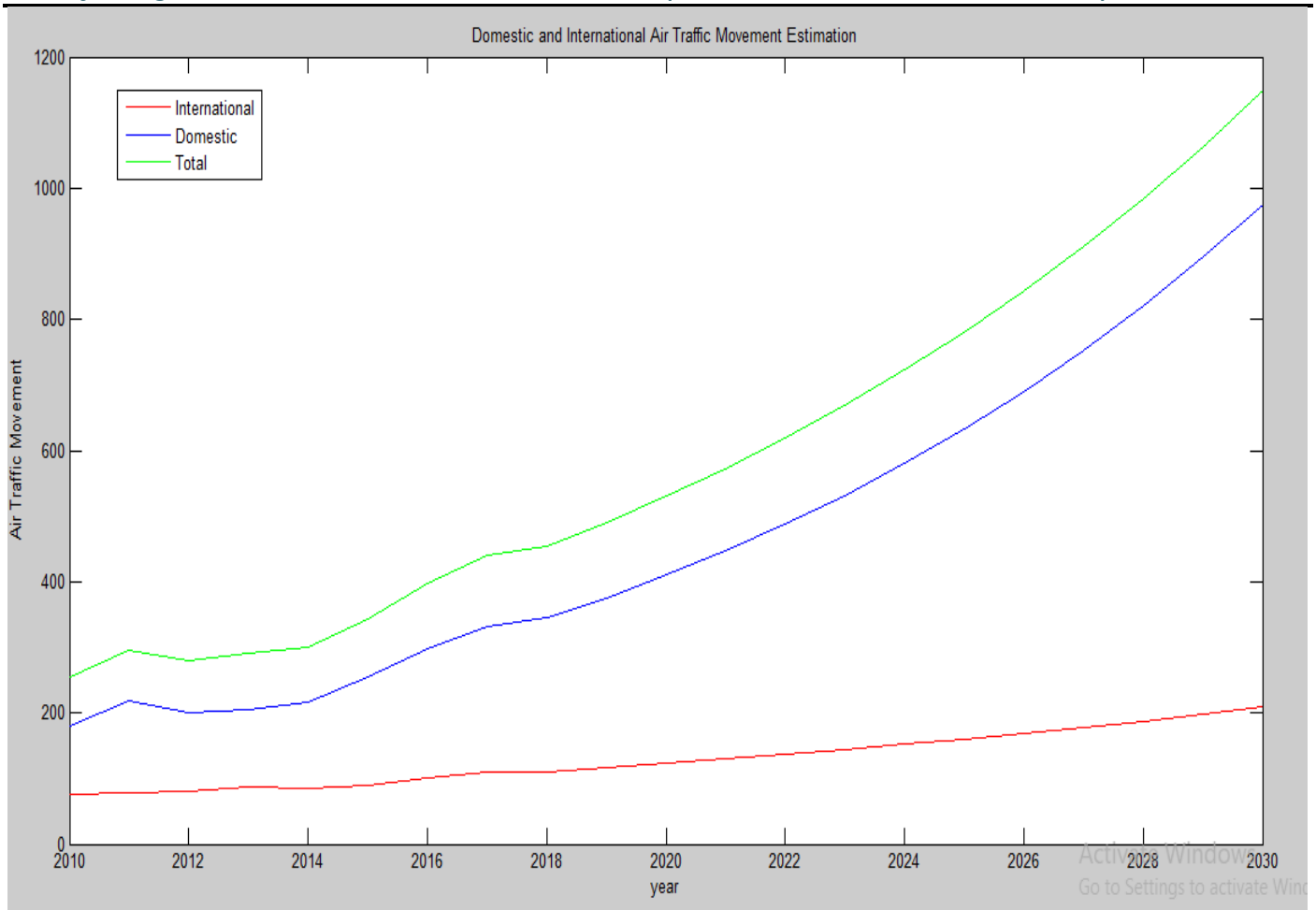

Figure 3.2 Domestic and International Air Traffic Movement Estimation (Growth Trend function)

4. R-square Value /Coefficient of Determinant

$SE_{Line} = (y_1 - (mx_1 + b))^2 + (y_2 - (mx_2 + b))^2 + \ldots + (y_n - (mx_n + b))^2$ (1)

How much (what %) of the total variation in Y is describe by the variation in X.

Total variation in Y: $SE_{\bar{y}} = (y_1 - \bar{y})^2 + (y_2 - \bar{y})^2 + \ldots\ldots + (y_n - \bar{y})^2$ (2)

$SE_{\bar{y}}$ = What percentage of the total variation in Y is not describe by the variation in X (or by the regression line)

Method		Parameters						R^2	Selection
Passenger Traffic	Linear	$\emptyset_1$	26.875	$\emptyset_2$	4.825	$\emptyset_3$		0.9998	Selected
	Quadratic	$\emptyset_1$	32.0958	$\emptyset_2$	-0.3959	$\emptyset_3$	0.7409	0.9809	
	Growth	$\emptyset_1$	27.9754	$\emptyset_2$	2.2274	$\emptyset_3$		0.9531	
Freight Traffic	Linear	$\emptyset_1$	503.0833	$\emptyset_2$	57.1369	$\emptyset_3$		0.8500	
	Quadratic	$\emptyset_1$	580.3708	$\emptyset_2$	-20.1434	$\emptyset_3$	11.0411	0.9770	Selected
	Growth	$\emptyset_1$	509.5198	$\emptyset_2$	2.1757	$\emptyset_3$		-2.066	
Air Traffic Movement (ATM)	Linear	$\emptyset_1$	242.0833	$\emptyset_2$	23.9369	$\emptyset_3$		0.8423	
	Quadratic	$\emptyset_1$	272.8708	$\emptyset_2$	-6.8506	$\emptyset_3$	4.3982	0.9560	Selected
	Growth	$\emptyset_1$	244.5354	$\emptyset_2$	1.0804	$\emptyset_3$		0.8857	

$\bar{y}$ = Mean Variation

SE_{Line} = Total square error between points and line.

R-square Value /Coefficient of determinant = $1 - \frac{SE_{Line}}{SE_{\bar{y}}}$ (3)

APPENDIX 1 A. Mathematical model selection using Decomposition Technique

APPENDIX 2: Curve estimation algorithm.

1) **Linear** $E(Y_t) = \emptyset_1 + \emptyset_2 t$
2) **Quadratic** $E(Y_t) = \emptyset_1 + \emptyset_2 t + \emptyset_3 t^2$
3) **Growth** $E(Y_t) = \emptyset_1 \emptyset_2^t$

5. CONCLUSION

Forecasting is a very important technique in determining or predicting the future trend of data required for maintaining or designing airport. There are many different methods of forecasting but in the study is restricted to only three different decomposition technique. According to 'Times of India' Passenger Traffic of Delhi Airport saw 1.9crore International flyer and 4.9crore Domestic flyer in 2019. Overall Passenger Traffic of 2019 was 6.8crore. By comparing from our data Linear trend function will give the best-estimated solution of 6.54crore. In this study linear trend curve estimation method is selected for forecasting "Passenger Traffic" as R^2 value was 0.998. Quadratic trend estimation for "Air Traffic Movement" and "Freight Traffic Movement" because the R^2 value of quadratic trend close to unity. From our estimation, we conclude that as these three parameters for air traffic volume is increasing rapidly thus airport parameter also need to increase by some estimation. But due to external uncertain effect due Covid19 pandemic the analysis of the data may vary.

6. REFERENCES

[1] Association of Private Airport Operation (APAO) https://www.apaoindia.com/ .

[2] Emrah ÖNDER*, Sultan KUZU. Forecasting Air Traffic Volumes Using Smoothing Techniques Journal of Aeronautics and Space Technology January 2014 Volume 7 Number 1 (65-85)

[3] National Programme on Technology Enhanced Learning>>Mat lab Programming for Numerical Computation.

[4] https://cargo.newdelhiairport.in/about