Forecasting and Analysing Number of Passengers of Pune Metro

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MOTIVATION

Time series is a series of statistical observations arranged in chronological order. Study of time series help us to study past behaviors of variables under study, helps in forecasting the value of favorable variable and also helps in comparing two time related data. Time series can be helpful in many fields such as in business planning and decision making, inventory, scheduling of purchase and sales, comparison between national income and cost of living and many more. These large amount of data when studied properly and analyzed carefully can be useful in many future predictions and may help to avoid losses over a period of time. We selected this project to get a glimpse of application of time series on metro. We can use time series to predict number of passengers and help in preplanned actions or tactics for increase or decrease in no. of passengers.

ABSTRACT

In our daily life we come across many events that are time dependent. Time series a mathematical statistical tool to study series of these time related data in an order and is very useful in analyzing the periodic variations and helps in data based predictions. Time series is applicable in day to day life as well as in many fields such as accounting, manufacturing, weather forecast, sales forecasting etc.

In this project we have applied various methods of time series on the newly build Pune metro station which has completed a total of 10 stations. The response for metro was indecisive on whether it was a profitable or non-profitable initiative. Our main aim of this project is to try to predict the number of passengers to use metro over a period of time and help in developing schemes for the passengers beforehand if there will be increase in the number also whether the frequency of trains should be increased in the stipulated time. Government is encouraging people to use public transport as much as possible. So on the behalf of this project we will be able to suggest the increase or decrease in passengers so the government will be able to use the data and reduce or increase the valuable sources that is being used.

This project uses time series to study number of passengers using metro everyday and thereby help in estimating the number of passengers that may use metro in future. From the data collected it is observed that Sundays have the highest number of passengers. This project uses Moving Average (MA), Exponential smoothening to smoothen out any cyclic, seasonal or irregular fluctuations. Auto regressive Models (AR) gives intuitive appeal by suggesting simple model which considers interlinks. Autoregressive integrated moving average (ARIMA) models predict future values based on past values and help in smoothening lagged AR values The Holt-Winters algorithm is used for forecasting and It is a time-series forecasting method.

KEYWORDS: Metro, Time Series, AR, MA, Exponential smoothening, ARIMA, Halt Winters.

DATA COLLECTION: - Metro office, PUNE

INTRODUCTION

Whether travelling to work, going shopping, popping into town to meet with friends or getting home safely after a good night out, using public transport can be less stressful and more relaxing than driving. It also helps the environment. There are many benefits to using public transport. Here are some good reasons why you should ditch the car for public transport:

- you can enjoy a less stressful journey by letting someone else do the driving
- you don't have to worry about finding a parking space
- it reduces congestion in towns and cities
- using public transport is cheaper than owning and operating a car
- no more sitting in traffic jams in rush hour thanks to bus lanes and other bus priority measures

However still people uses private transportations so to increase use of public transport various schemes or tactics should be used. Hence using time series we could predict increase in number of passengers and avoid any inconvenience. Researchers have previously used time series to predict various data and increase the efficiency of various sectors.

OBJECTIVE

1) To use time series to predict and estimate the increase or decrease of number of customers.
2) To check the major variation in various days of week
3) To check whether there is a need to increase the frequency
4) What will be the predicted number of passengers?
5) Is there a need to increase schemes and awareness among people about metro

THE DATA

The following is the data that we collected from the official pune maha metro office regarding passengers in phugewadi and vanaz stations.

PHUGEWADI

t1	t2	date	passenger on date	cumulative
	21:00	3/6/2022	10570	10570
8:00	21:00	3/7/2022	5688	16258
8:00	21:00	3/8/2022	16653	32911
8:00	21:00	3/9/2022	5659	38570
8:00	21:00	3/10/2022	5566	44136
8:00	21:00	3/11/2022	4038	48174
8:00	21:00	3/12/2022	11189	59363
8:00	22:00	3/13/2022	22814	82177
8:00	22:00	3/14/2022	5301	87478
8:00	21:00	3/15/2022	4182	91660
8:00	21:00	3/16/2022	2912	94572
8:00	21:00	3/17/2022	2775	97347
8:00	21:00	3/18/2022	5526	102873
8:00	21:00	3/19/2022	5461	108334
8:00	22:00	3/20/2022	11929	120263
8:00	22:00	3/21/2022	2200	122463
8:00	21:00	3/22/2022	2241	124704
8:00	21:00	3/23/2022	1964	126668
8:00	21:00	3/24/2022	2583	129251
8:00	21:00	3/25/2022	1849	131100
8:00	21:00	3/26/2022	4070	135170
8:00	21:00	3/27/2022	8023	143193

8:00	21:00	3/28/2022	1944	145137
8:00	21:00	3/29/2022	3057	148194

MANN-KENDALL TEST

To Test:

H0: There is no trend present in data

H1: There is trend(increasing or decreasing)present in data

Stations	tau	P value	Decision(<0.05)
Phugewadi	-0.457	0.0019316	H0 Rejected
Vanaz	-0.551	0.00018006	H0 Rejected

Interpretation:

As H0 is rejected in both stations a trend is present.

VANAZ

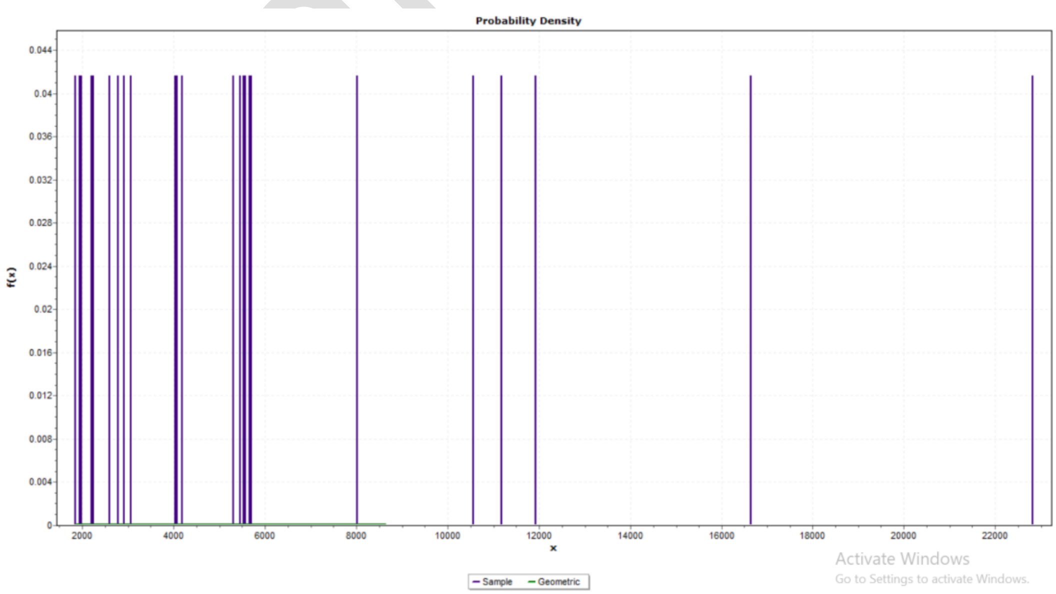
t1	t2	date	on date	passenger cumulative
	21:00	3/6/2022	27182	27182
8:00	21:00	3/7/2022	21917	49099
8:00	21:00	3/8/2022	25417	74516
8:00	21:00	3/9/2022	14664	89180
8:00	21:00	3/10/2022	14308	103488
8:00	21:00	3/11/2022	12580	116068
8:00	21:00	3/12/2022	30187	146255
8:00	22:00	3/13/2022	44536	190791
8:00	22:00	3/14/2022	12548	203339
8:00	21:00	3/15/2022	10108	213447
8:00	21:00	3/16/2022	8832	222279
8:00	21:00	3/17/2022	6727	229006
8:00	21:00	3/18/2022	12998	242004
8:00	21:00	3/19/2022	15384	257388
8:00	22:00	3/20/2022	26121	283509
8:00	22:00	3/21/2022	6475	289984
8:00	21:00	3/22/2022	6401	296385
8:00	21:00	3/23/2022	6336	302721
8:00	21:00	3/24/2022	6321	309042
8:00	21:00	3/25/2022	5780	314822
8:00	21:00	3/26/2022	11179	326001
8:00	21:00	3/27/2022	19272	345273

8:00	21:00	3/28/2022	6096	351369
8:00	21:00	3/29/2022	4959	356328

Phugewadi station

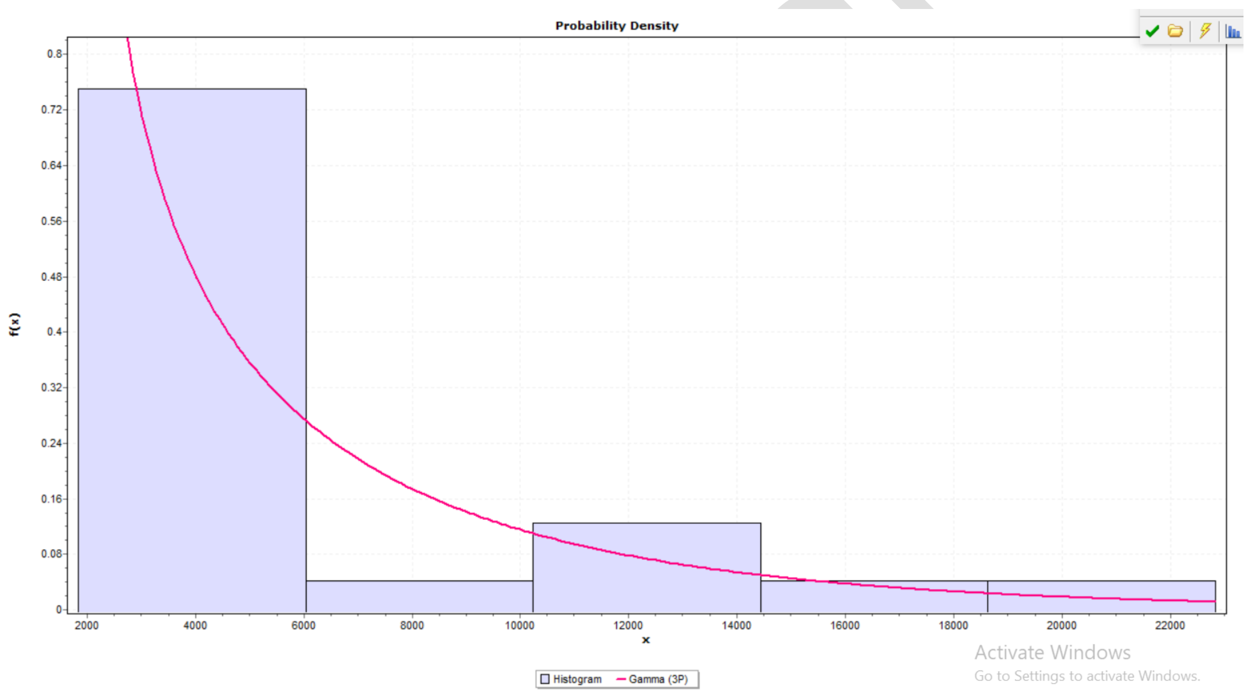
Graph fitted distributions:

Discrete



P=1.6192E-4

Continuous



DISCRETE	**GEOMETRIC**	**PARAMETER** **P=1.6192E-4**	**STATISTIC=0.21721**

CONTINOUS	GAMMA(3P)	PARAMETER ALPHA=0.6057 BETA=6631.4 GAMMA=1849	STATISTIC=0.09487

Auto-regressive model

AR (1) – $\mathbf{Y_t = a_1\, Y_{t-1} + a_2 Y_{t-2} + \dots\dots + a_k Y_{t-k} + b + \varepsilon}$

Various aic of the given data

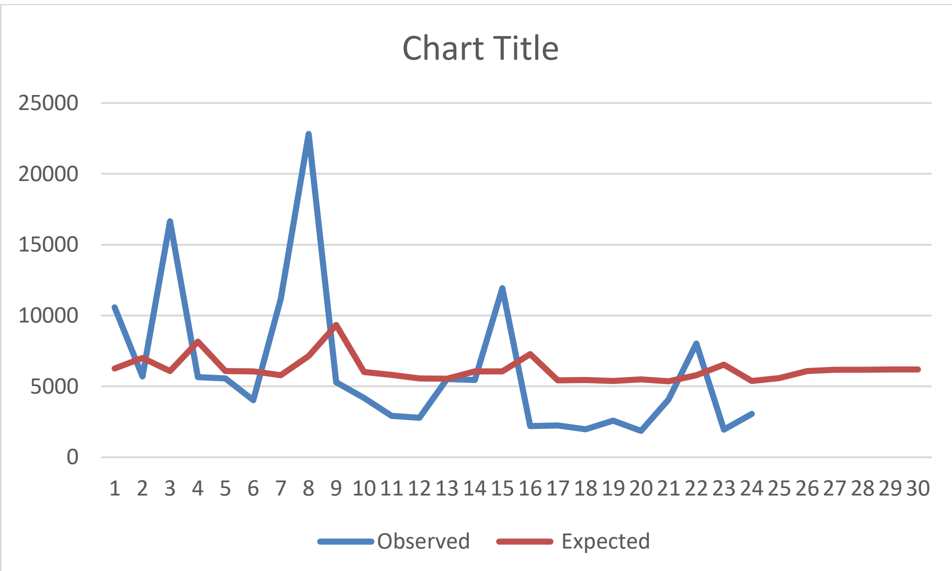
Sr. No.	*AR Model*	*AIC*
1	arima(b, order = c(1,0,0))	482.6
2	arima(b, order = c(2,0,0))	484.59
3	arima(b, order = c(3,0,0))	486.25
4	arima(b, order = c(4,0,0))	488.15
5	arima(b, order = c(5,0,0))	487.94
6	arima(b, order = c(6,0,0))	489.83
7	arima(b, order = c(7,0,0))	484.43
8	arima(b, order = c(8,0,0))	483.63
9	arima(b, order = c(9,0,0))	485.27
10	arima(b, order = c(10,0,0))	486.81
11	arima(b, order = c(11,0,0))	488.53
12	arima(b, order = c(12,0,0))	486.06
13	arima(b, order = c(13,0,0))	487.89
14	arima(b, order = c(14,0,0))	489.37
15	arima(b, order = c(15,0,0))	485.43

optimum model :arima(b, order = c(1,0,0))

aic = 482.6

Sr. No.	*Observed*	*Expected*
1	10570	6266.401
2	5688	7017.678
3	16653	6092.39
4	5659	8170.592
5	5566	6086.893
6	4038	6069.267
7	11189	5779.664
8	22814	7134.997
9	5301	9338.29
10	4182	6019.041
11	2912	5806.957
12	2775	5566.253
13	5526	5540.287
14	5461	6061.686
15	11929	6049.366
16	2200	7275.25
17	2241	5431.307
18	1964	5439.078
19	2583	5386.578
20	1849	5503.897
21	4070	5364.782
22	8023	5785.729
23	1944	6534.944
24	3057	5382.787

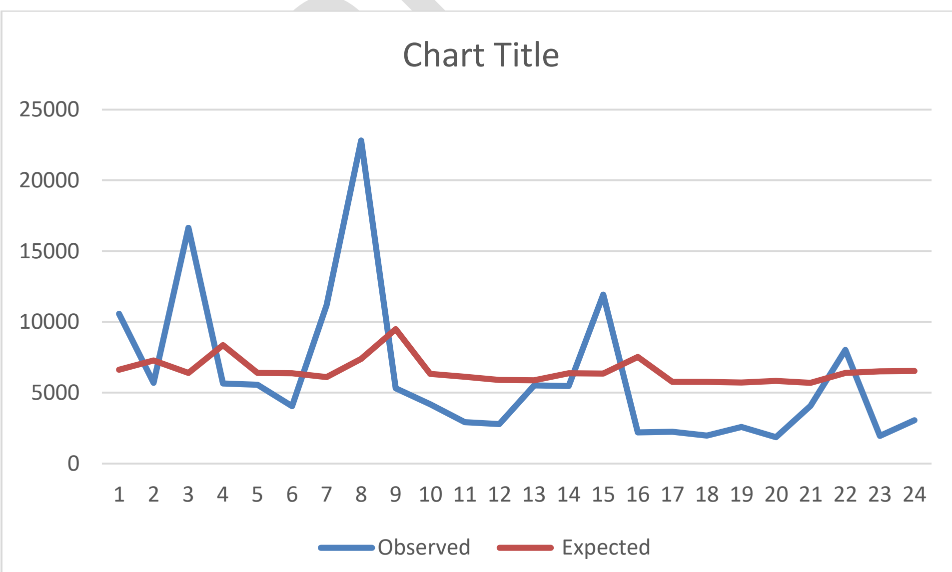
25		5593.735
26		6074.524
27		6165.648
28		6182.919
29		6186.192
30		6186.812



Split train test

Sr. No.	***Observed***	***Expected***
1	10570	6613.521
2	5688	7273.025
3	16653	6392.534
4	5659	8370.12
5	5566	6387.304

6	4038	6370.531
7	11189	6094.95
8	22814	7384.664
9	5301	9481.284
10	4182	6322.737
11	2912	6120.921
12	2775	5891.87
13	5526	5867.162
14	5461	6363.317
15	11929	6351.594
16	2200	7518.126
17	2241	5763.458
18	1964	5770.853
19	2583	5720.895
20	1849	5832.534
21	4070	5700.154
22	8023	6394.726
23	1944	6519.996
24	3057	6542.588



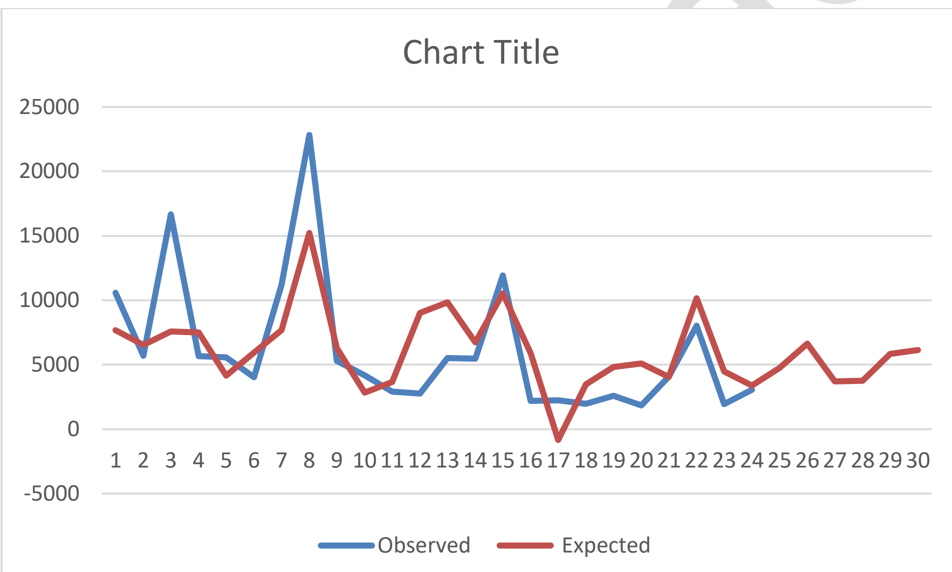
MA model

Sr. No.	*MA model*	*AIC*
1	arima(b, order = c(0,0,1))	482.62
2	arima(b, order = c(0,0,2))	484.54
3	arima(b, order = c(0,0,3))	484.84
4	arima(b, order = c(0,0,4))	485.90
5	arima(b, order = c(0,0,5))	482.20
6	arima(b, order = c(0,0,6))	484.14
7	arima(b, order = c(0,0,7))	483.42
8	arima(b, order = c(0,0,8))	485.03
9	arima(b, order = c(0,0,9))	485.94
10	arima(b, order = c(0,0,10))	487.52
11	arima(b, order = c(0,0,11))	489.44
12	arima(b, order = c(0,0,12))	489.85
13	arima(b, order = c(0,0,13))	491.57
14	arima(b, order = c(0,0,14))	493.51
15	arima(b, order = c(0,0,15))	494.28
16	arima(b, order = c(0,0,16))	495.46
17	arima(b, order = c(0,0,17))	497.14
18	arima(b, order = c(0,0,18))	498.81
19	arima(b, order = c(0,0,19))	500.81

20	arima(b, order = c(0,0,20))	502.66
21	arima(b, order = c(0,0,21))	503.44
22	arima(b, order = c(0,0,22))	505.38
23	arima(b, order = c(0,0,23))	507.34
24	arima(b, order = c(0,0,24))	509.30
25	arima(b, order = c(0,0,25))	510.88

Sr. No.	***Observed***	***Expected***
1	10570	6266.401
2	5688	7017.678
3	16653	6092.39
4	5659	8170.592
5	5566	6086.893
6	4038	6069.267
7	11189	5779.664
8	22814	7134.997
9	5301	9338.29
10	4182	6019.041
11	2912	5806.957
12	2775	5566.253
13	5526	5540.287
14	5461	6061.686
15	11929	6049.366
16	2200	7275.25
17	2241	5431.307
18	1964	5439.078

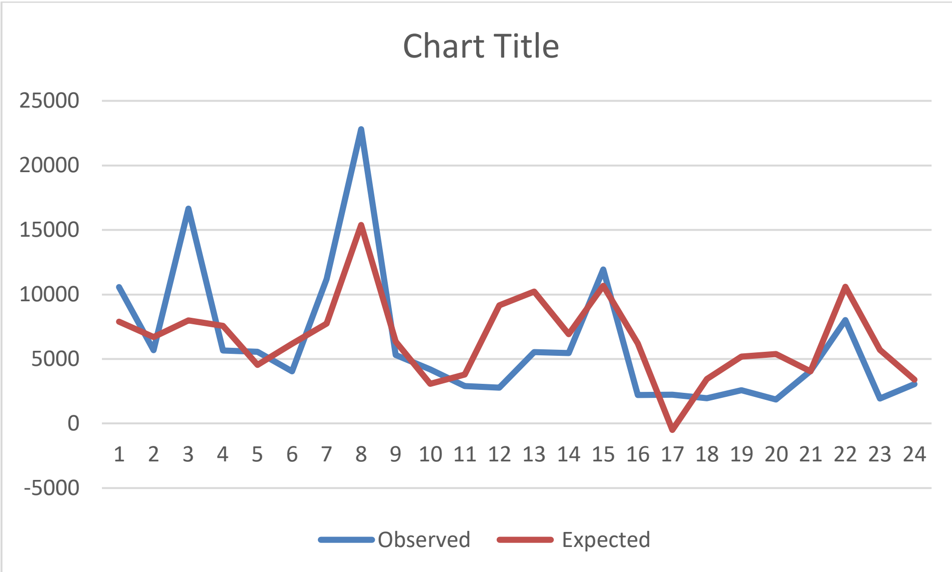
19	2583	5386.578
20	1849	5503.897
21	4070	5364.782
22	8023	5785.729
23	1944	6534.944
24	3057	5382.787
25		5593.735
26		6074.524
27		6165.648
28		6182.919
29		6186.192
30		6186.812



Split train test

Sr. No.	***Observed***	***Expected***
1	10570	7890.384
2	5688	6710.642
3	16653	7982.151

4	5659	7579.936
5	5566	4543.744
6	4038	6187.67
7	11189	7749.082
8	22814	15378.09
9	5301	6361.361
10	4182	3081.134
11	2912	3787.109
12	2775	9157.608
13	5526	10235.85
14	5461	6926.017
15	11929	10669.31
16	2200	6205.073
17	2241	-498.517
18	1964	3445.796
19	2583	5176.931
20	1849	5392.639
21	4070	4036.992
22	8023	10597.74
23	1944	5711.391
24	3057	3410.797



Arima

$\Phi(B)Xt = \Theta(B)\omega t$

Phugewadi	
Arima Model	***AIC***
arima(x = t, order = c(1, 0, 5))	484.11
arima(x = t, order = c(2, 0, 5))	484.39
arima(x = t, order = c(3, 0, 6))	483.43
arima(x = t, order = c(4, 0, 6))	485.07
arima(x = t, order = c(5, 0, 1))	485.57
arima(x = t, order = c(6, 0, 4))	486.95
arima(x = t, order = c(7, 0, 1))	484.54
arima(x = t, order = c(8, 0, 1))	481.87
arima(x = t, order = c(9, 0, 1))	483.87
arima(x = t, order = c(10, 0, 1))	485.16

Phugewadi:

Model fitting-

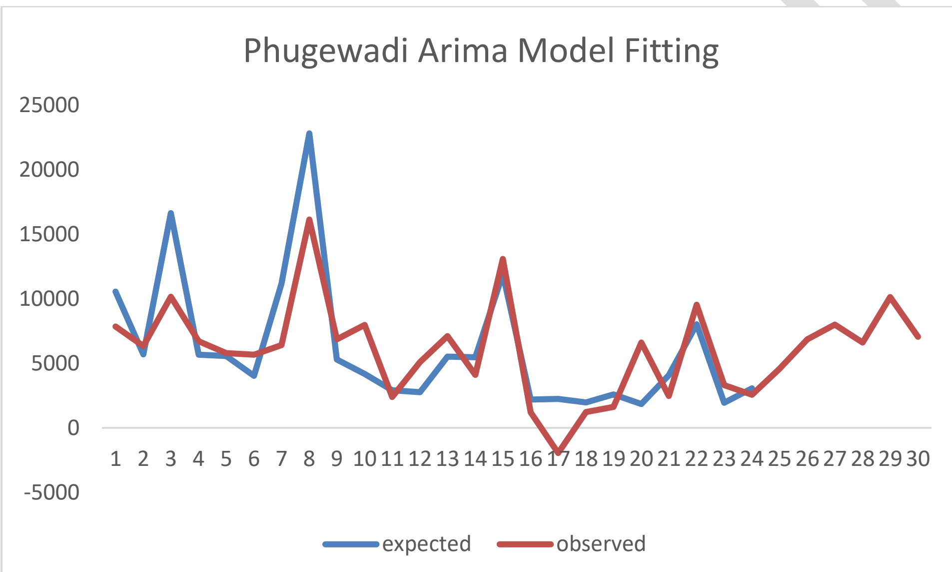
MA (1) = $X_t = \mu + w_t + \theta_1 w_{t-1} + \theta_2 w_{t-2} + \ldots + \theta_q w_{t-q}$

Model = arima(x = t, order = c(8, 0, 1))

AIC = 508.52

	expected	observed
1	10570	7859.197
2	5688	6341.292
3	16653	10169.31
4	5659	6705.862
5	5566	5789.736
6	4038	5665.863
7	11189	6418.853
8	22814	16146.11
9	5301	6855.14
10	4182	7986.39
11	2912	2387.924
12	2775	5088.539
13	5526	7105.527
14	5461	4103.546
15	11929	13083.25
16	2200	1202.797
17	2241	-1962.13
18	1964	1220.191
19	2583	1628.97
20	1849	6616.362
21	4070	2475.776

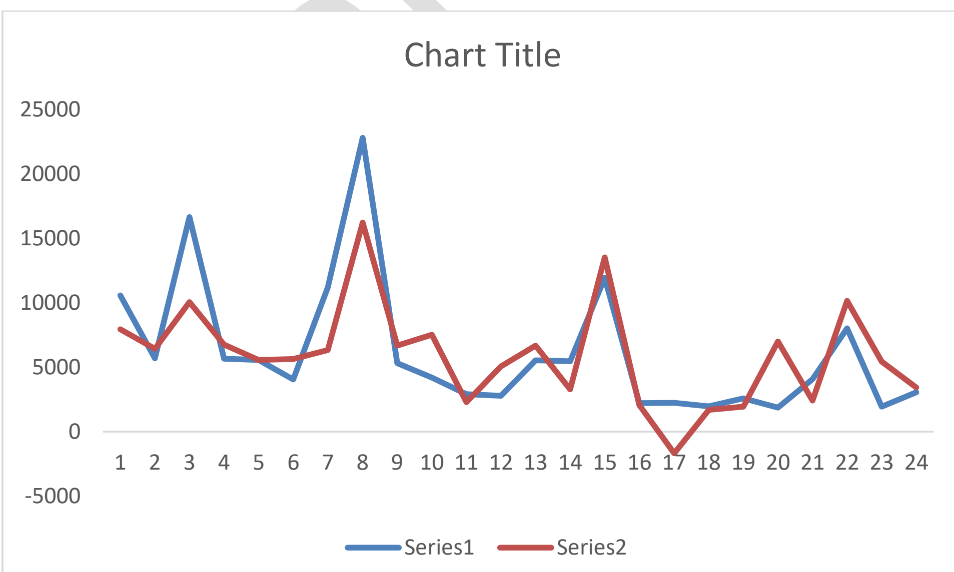
22	8023	9541.87
23	1944	3303.549
24	3057	2565.559
25		4572.09
26		6849.646
27		8014.572
28		6609.864
29		10142.08
30		7070.526



Split, Train and Test-

	b	D
1	10570	7936.762
2	5688	6416.803
3	16653	10060.53
4	5659	6751.299
5	5566	5568.65

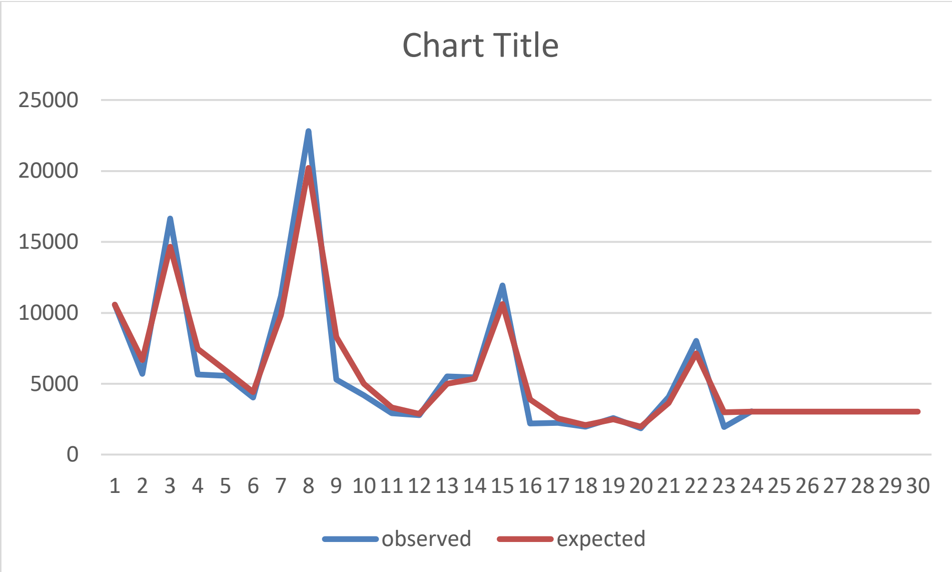
6	4038	5622.045
7	11189	6327.922
8	22814	16225.19
9	5301	6676.673
10	4182	7517.383
11	2912	2275.755
12	2775	5072.136
13	5526	6682.753
14	5461	3277.888
15	11929	13534.28
16	2200	2068.155
17	2241	-1699.73
18	1964	1684.34
19	2583	1927.791
20	1849	7002.485
21	4070	2412.454
22	8023	10144.62
23	1944	5422.952
24	3057	3413.532



Exponential smoothing

sr. no.	observed	expected	error squared
1	10570	10570	0
2	5688	6664.4	953357
3	16653	14655.28	3990885
4	5659	7458.256	3237322
5	5566	5944.451	143225.2
6	4038	4419.29	145382.1
7	11189	9835.058	1833159
8	22814	20218.21	6738115
9	5301	8284.442	8900926
10	4182	5002.488	673200.6
11	2912	3330.098	174805.9
12	2775	2886.02	12325.44
13	5526	4998.004	278779.8
14	5461	5368.401	8574.575
15	11929	10616.88	1721659
16	2200	3883.376	2833755
17	2241	2569.475	107895.8
18	1964	2085.095	14664
19	2583	2483.419	9916.376
20	1849	1975.884	16099.55
21	4070	3651.177	175412.7
22	8023	7148.635	764514.2
23	1944	2984.927	1083529
24	3057	3042.585	207.7922
25		3042.585	
26		3042.585	
27		3042.585	
28		3042.585	
29		3042.585	

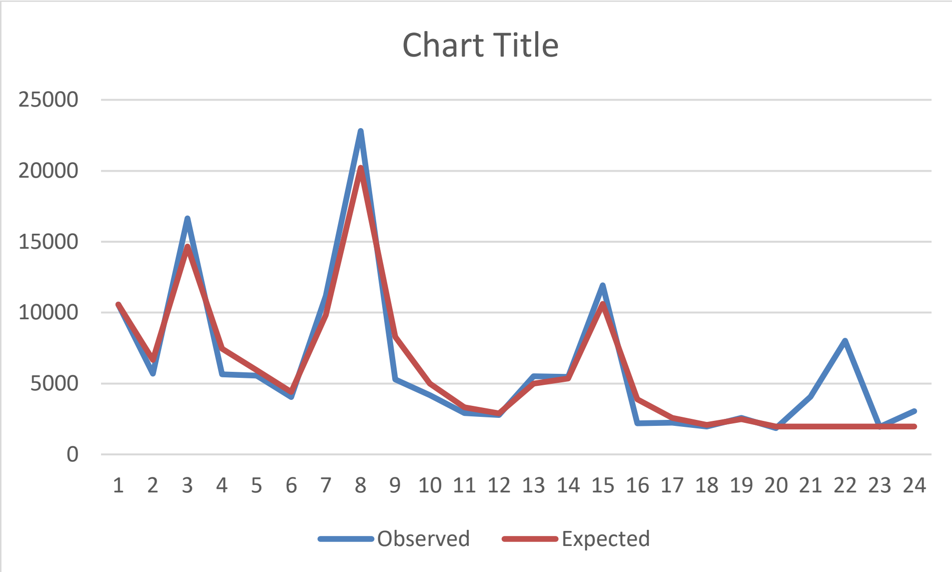
		3042.585	



Split train test

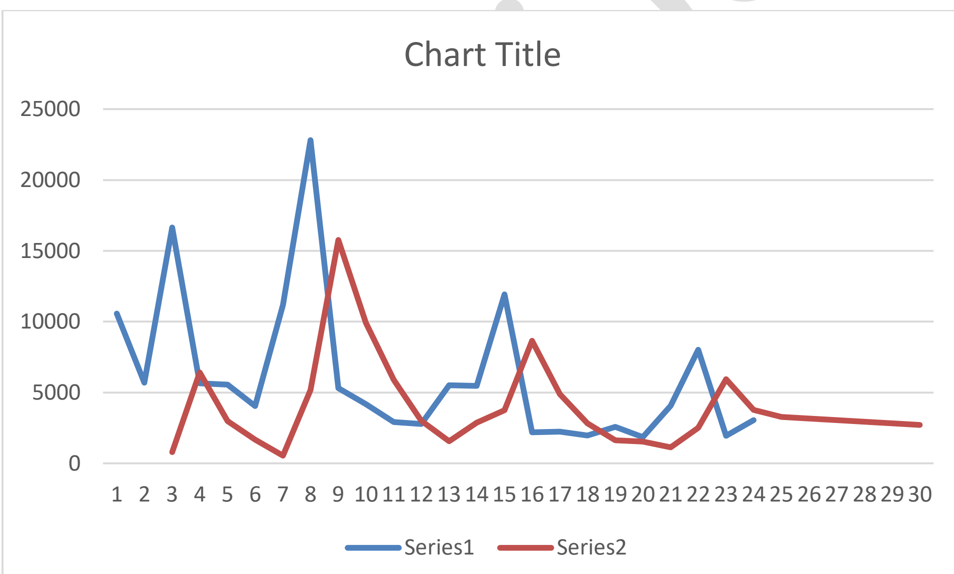
Sr. No.	***Observed***	***Expected***
1	10570	10570
2	5688	6664.4
3	16653	14655.28

4	5659	7458.256
5	5566	5944.451
6	4038	4419.29
7	11189	9835.058
8	22814	20218.21
9	5301	8284.442
10	4182	5002.488
11	2912	3330.098
12	2775	2886.02
13	5526	4998.004
14	5461	5368.401
15	11929	10616.88
16	2200	3883.376
17	2241	2569.475
18	1964	2085.095
19	2583	2483.419
20	1849	1975.884
21	4070	1975.884
22	8023	1975.884
23	1944	1975.884
24	3057	1975.884



Sr. No.	*Observed*	*Expected*
1	10570	
2	5688	
3	16653	806
4	5659	6421.776
5	5566	2990.328
6	4038	1676.278
7	11189	538.3895
8	22814	5182.925
9	5301	15766.15
10	4182	9913.189
11	2912	5904.605
12	2775	3002.836
13	5526	1563.226
14	5461	2871.548
15	11929	3759.207
16	2200	8663.131

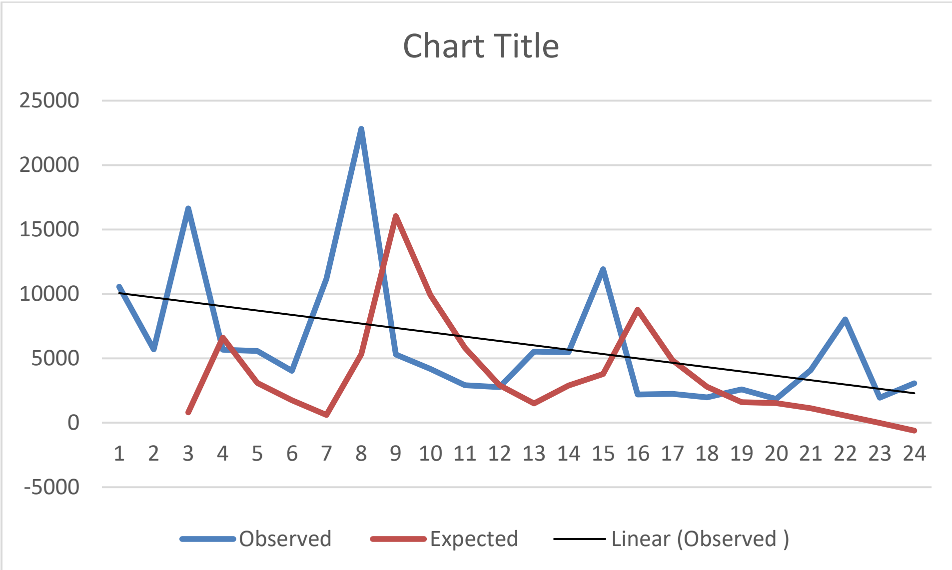
17	2241	4881.861
18	1964	2834.952
19	2583	1634.575
20	1849	1531.942
21	4070	1128.118
22	8023	2502.229
23	1944	5947.803
24	3057	3765.243
25		3271.66
26		3159.837
27		3048.014
28		2936.191
29		2824.368
30		2712.545



Split train test

Sr. No.	*Observed*	*Expected*
1	10570	
2	5688	

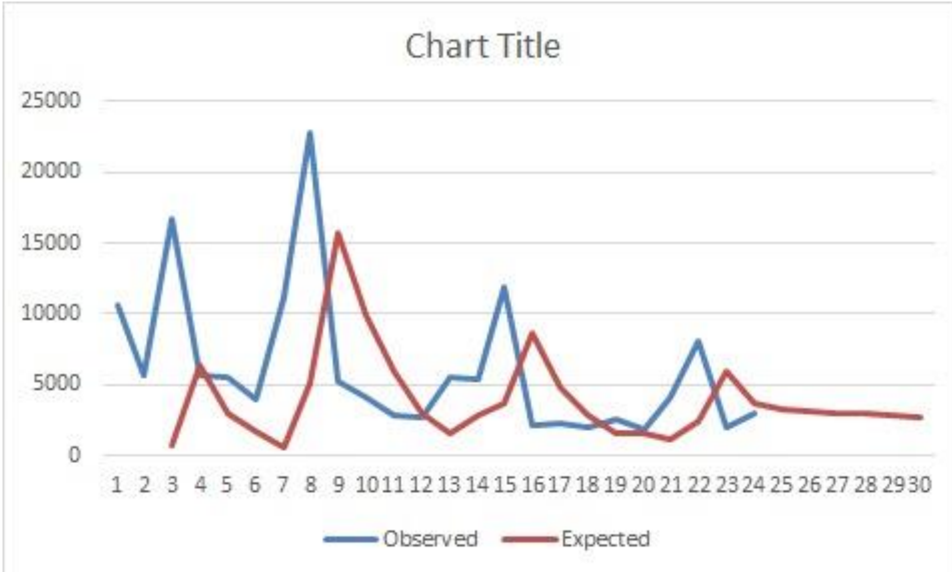
3	16653	806
4	5659	6613.361
5	5566	3081.772
6	4038	1749.538
7	11189	597.864
8	22814	5334.613
9	5301	16050.5
10	4182	9924.588
11	2912	5823.314
12	2775	2909.195
13	5526	1501.986
14	5461	2882.749
15	11929	3794.67
16	2200	8778.805
17	2241	4862.022
18	1964	2787.037
19	2583	1595.031
20	1849	1521.043
21	4070	1126.178
22	8023	551.3641
23	1944	-23.4498
24	3057	-598.264



Holt

Sr. No.	***Observed***	***Expected***
1	10570	10215.56
2	5688	9867.88
3	16653	9519.279
4	5659	9172.632
5	5566	8824.485
6	4038	8476.02
7	11189	8126.959
8	22814	7779.017
9	5301	7433.938
10	4182	7086.813
11	2912	6739.299
12	2775	6391.281

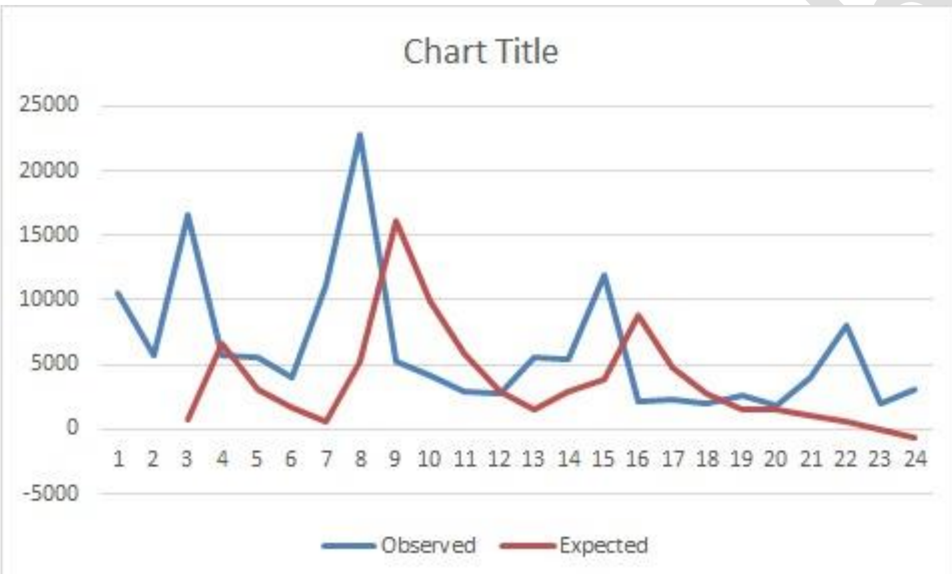
13	5526	6042.903
14	5461	5694.798
15	11929	5346.698
16	2200	5000.018
17	2241	4652.048
18	1964	4303.862
19	2583	3955.437
20	1849	3606.969
21	4070	3258.273
22	8023	2909.936
23	1944	2562.596
24	3057	2214.584
25		1866.815
26		1518.958
27		1171.1
28		823.2421
29		475.3845
30		127.5268



Split train test

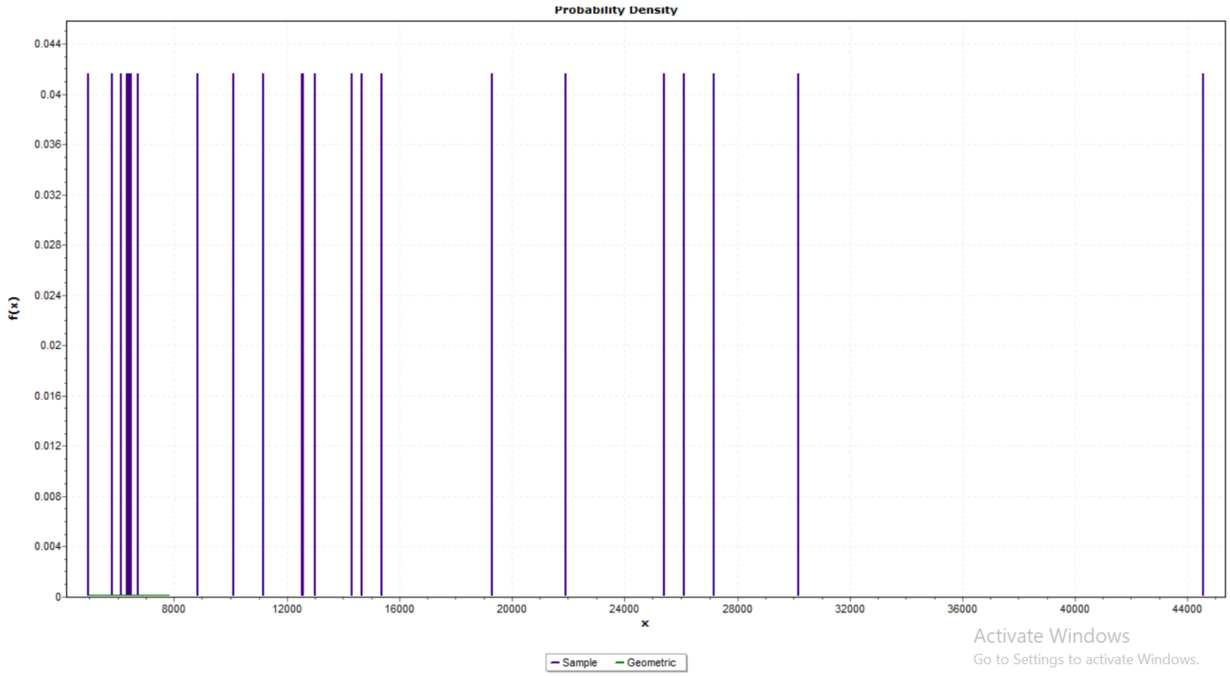
Sr. No.	*Observed*	*Expected*
1	10570	10633.27
2	5688	10201.27
3	16653	9766.833
4	5659	9338.176
5	5566	8904.434
6	4038	8470.51
7	11189	8035.655
8	22814	7604.501
9	5301	7180.251
10	4182	6748.184
11	2912	6315.554
12	2775	5882.209
13	5526	5448.686
14	5461	5016.592
15	11929	4584.707
16	2200	4156.637

17	2241	3724.218
18	1964	3291.863
19	2583	2859.444
20	1849	2427.467
21	4070	1995.297
22	8023	1563.385
23	1944	1131.474
24	3057	699.5623



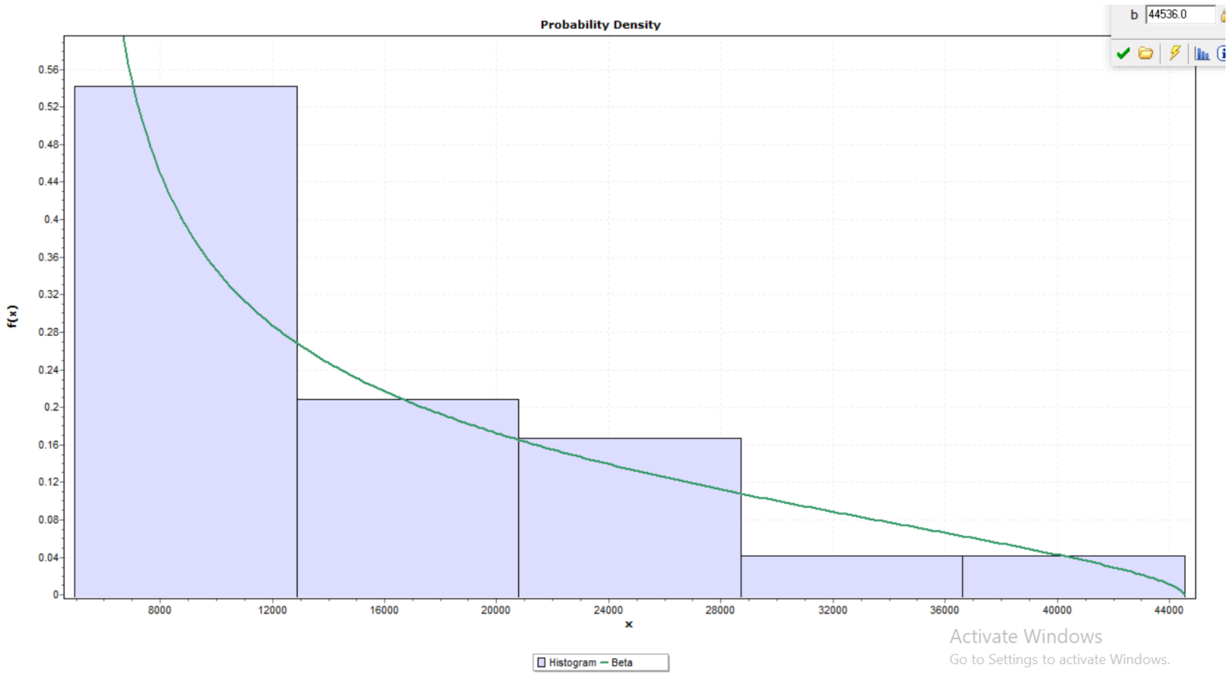
VANAZ

Fitted graph:



P=6.734E-04

CONTINOUS



STATISTIC:0.0976

DISCRETE	**GEOMETRIC**	**PARAMRTER** **P=6.7349E-5**	**STATISTIC=0.24232**
CONTINOUS	BETA	PARAMETER ALPHA1=0.5503 ALPHA2=1.599 A=4959.0,b=44536	STATISTIC=0.0976

Auto regressive model vanaz

Vanaz:

1) **AR MODEL**

AR (1) – $Y_t = a_1 Y_{t-1} + a_2 Y_{t-2} + \ldots\ldots + a_k Y_{t-k} + b + \varepsilon$

SR NO.	ORDER	AIC
1	arima(b, order = c(1,0,0))	510.62
2	arima(b, order = c(2,0,0))	511.96
3	arima(b, order = c(3,0,0))	513.96
4	arima(b, order = c(4,0,0))	515.92
5	arima(b, order = c(5,0,0))	517.06
6	arima(b, order = c(6,0,0))	518.42
7	arima(b, order = c(7,0,0))	513.04

8	arima(b, order = c(8,0,0))	510.16
9	arima(b, order = c(9,0,0))	511.65
10	arima(b, order = c(10,0,0))	513.46
11	arima(b, order = c(11,0,0))	514.91
12	arima(b, order = c(12,0,0))	514.04
13	arima(b, order = c(13,0,0))	516.02
14	arima(b, order = c(14,0,0))	518.02
15	arima(b, order = c(15,0,0))	517.42

Optimum model :arima(b, order = c(8,0,0))

Aic = 510.16

sr. no.	observed	Expected
1	27182	18817.75
2	21917	20325.3
3	25417	17980.69
4	14664	16976.53
5	14308	12507.69
6	12580	15208.83
7	30187	19089.93
8	44536	31353.35
9	12548	25089.17
10	10108	10311.24
11	8832	8385.549
12	6727	11872.27
13	12998	13116.4
14	15384	20180.45
15	26121	24988.89
16	6475	3845.511
17	6401	3746.162
18	6336	12860.61
19	6321	7279.516
20	5780	16817.41
21	11179	7898.316
22	19272	21051.22
23	6096	5958.041
24	4959	6947.101
		10322.44
		12582.2

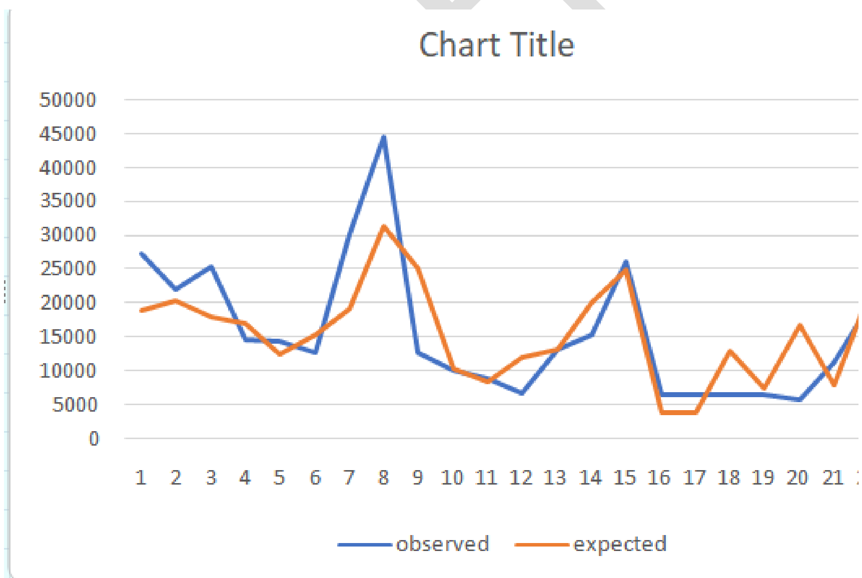
14400.4

15133.7

19391.5

10327.8

MSE=35237206.8

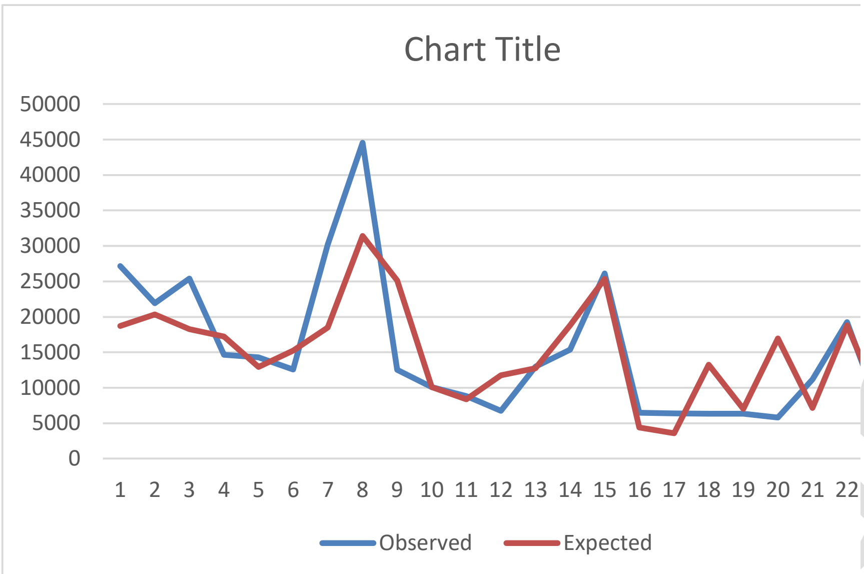


AR

$$\mathbf{Y_t = a_1\, Y_{t-1} + a_2 Y_{t-2} + \ldots\ldots + a_k Y_{t-k} + b + \varepsilon}$$

Sr. No.	Observed	Expected
1	27182	18714.7
2	21917	20360.24
3	25417	18273.76
4	14664	17220.87
5	14308	12910.68
6	12580	15257.98
7	30187	18508.11
8	44536	31406.83
9	12548	25123.49
10	10108	10105.27
11	8832	8371.397
12	6727	11762.27
13	12998	12739.34
14	15384	18827.03
15	26121	25361.57
16	6475	4395.814
17	6401	3572.242
18	6336	13251.28
19	6321	7030.99
20	5780	16973.17
21	11179	7147.676
22	19272	18821.55
23	6096	7300.778

24	4959	7325.191



MA MODELS:

2)MA MODEL

$X_t = \mu + w_t + \theta_1 w_{t-1} + \theta_2 w_{t-2} + \ldots + \theta_q w_{t-q}$

SR NO.	ORDER	AIC
1	arima(b, order = c(0,0,1))	510.1
2	arima(b, order = c(0,0,2))	512.05
3	arima(b, order = c(0,0,3))	514.04
4	arima(b, order = c(0,0,4))	514.58
5	arima(b, order = c(0,0,5))	512.5
6	arima(b, order = c(0,0,6))	513.5
7	arima(b, order = c(0,0,7))	512.76
8	arima(b, order = c(0,0,8))	512.36
9	arima(b, order = c(0,0,9))	513.56
10	arima(b, order = c(0,0,10))	515.41
11	arima(b, order = c(0,0,11))	517.29
12	arima(b, order = c(0,0,12))	518.14

13	arima(b, order = c(0,0,13))	520.12
14	arima(b, order = c(0,0,14))	521.89
15	arima(b, order = c(0,0,15))	522.78
16	arima(b, order = c(0,0,16))	524.59
17	arima(b, order = c(0,0,17))	526.02

optimum model : arima(b, order = c(0,0,1))

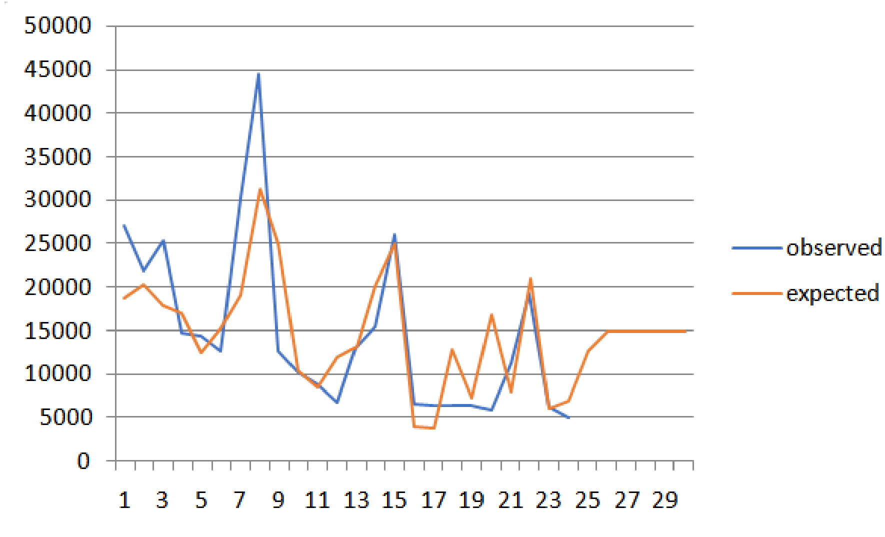
AIC=510.1

2) MA Model

$X_t = \mu + w_t + \theta_1 w_{t-1} + \theta_2 w_{t-2} + \ldots + \theta_q w_{t-q}$

sr. no.	observed	Expected
1	27182	18817.75
2	21917	20325.3
3	25417	17980.69
4	14664	16976.53
5	14308	12507.69
6	12580	15208.83
7	30187	19089.93
8	44536	31353.35
9	12548	25089.17
10	10108	10311.24

11	8832	8385.549
12	6727	11872.27
13	12998	13116.4
14	15384	20180.45
15	26121	24988.89
16	6475	3845.511
17	6401	3746.162
18	6336	12860.61
19	6321	7279.516
20	5780	16817.41
21	11179	7898.316
22	19272	21051.22
23	6096	5958.041
24	4959	6947.101
25		12707.79
26		14975.76
27		14975.76
28		14975.76
29		14975.76
30		14975.76

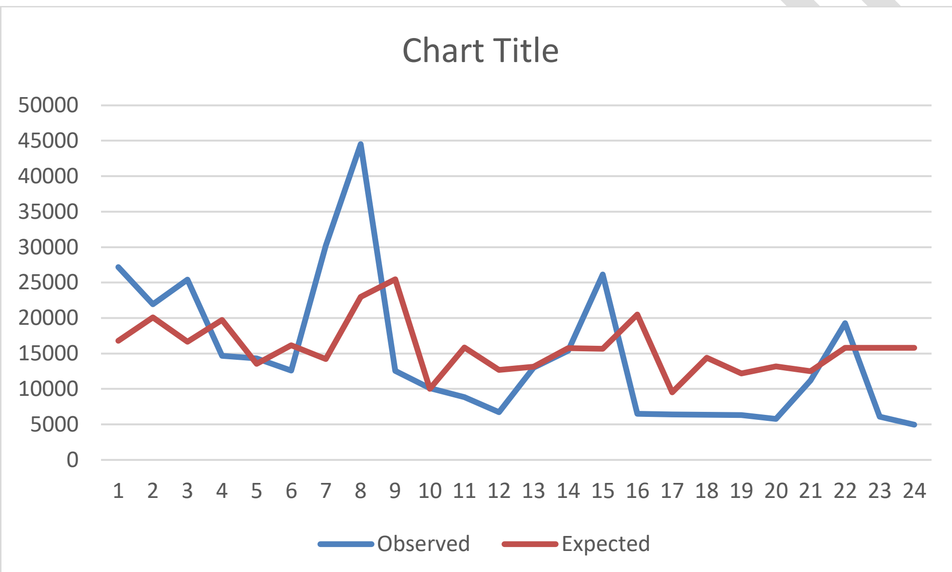


MA

$X_t = \mu + w_t + \theta_1 w_{t-1} + \theta_2 w_{t-2} + \ldots + \theta_q w_{t-q}$

Sr. No.	Observed	Expected
1	27182	16808.31
2	21917	20086.73
3	25417	16649.81
4	14664	19726.73
5	14308	13547.9
6	12580	16155.09
7	30187	14212.99
8	44536	22971.73
9	12548	25476.42
10	10108	10022.14
11	8832	15853.13
12	6727	12668.88
13	12998	13152.43
14	15384	15745.47
15	26121	15652.71

16	6475	20504.94
17	6401	9528.614
18	6336	14413.35
19	6321	12195.64
20	5780	13182.56
21	11179	12497.98
22	19272	15814.66
23	6096	15814.66
24	4959	15814.66



ARIMA

Vanaz:

Model fitting-

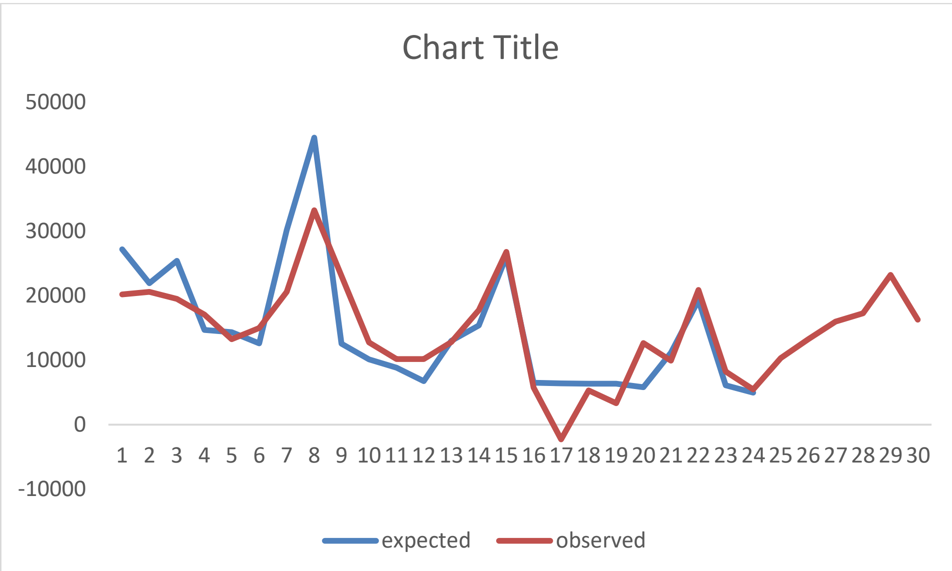
Model = arima(x = t, order = c(8, 0, 1))

AIC = 508.52

	expected	observed

1	27182	20171.03
2	21917	20595.38
3	25417	19505.57
4	14664	17062.86
5	14308	13252.98
6	12580	14960.85
7	30187	20605.71
8	44536	33250.68
9	12548	23077.16
10	10108	12748.11
11	8832	10148.36
12	6727	10173.23
13	12998	12783.6
14	15384	17739.07
15	26121	26800.34
16	6475	5751.043
17	6401	-2290.61
18	6336	5302.279
19	6321	3305.705
20	5780	12622.18
21	11179	9930.407
22	19272	20863.22
23	6096	8244.922
24	4959	5468.768
25		10335.42
26		13221.72
27		15949.68
28		17280.65
29		23227.09
30		16280.54

#Graph-

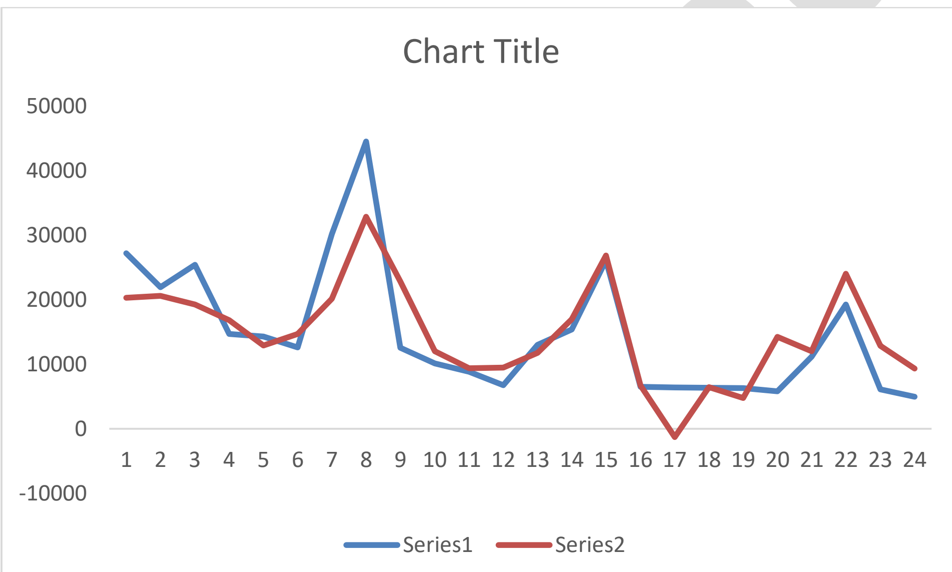


Split, Train and Test-

	b	d
1	27182	20304.22
2	21917	20593.72
3	25417	19251.31
4	14664	16824.06
5	14308	12919.2
6	12580	14671.25
7	30187	20164.55
8	44536	32875.78
9	12548	22829.86
10	10108	12007.25
11	8832	9380.851
12	6727	9468.063
13	12998	11783.75
14	15384	16958.29

15	26121	26845.12
16	6475	6690.431
17	6401	-1316.84
18	6336	6440.092
19	6321	4770.908
20	5780	14216.48
21	11179	11992.24
22	19272	24006.37
23	6096	12849.22
24	4959	9349.168

#Graph-



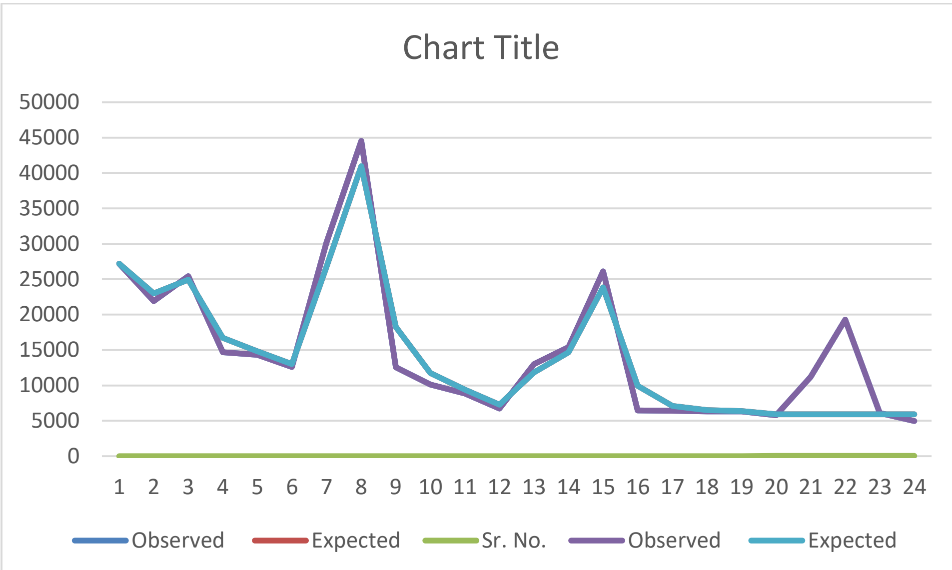
EXPONENTIAL SMOOTHENING

SPLIT AND TRAIN

Expo

Sr. No.	Observed	Expected
1	27182	27182
2	21917	22970
3	25417	24927.6
4	14664	16716.72
5	14308	14789.74
6	12580	13021.95
7	30187	26753.99
8	44536	40979.6
9	12548	18234.32
10	10108	11733.26
11	8832	9412.253
12	6727	7264.051
13	12998	11851.21
14	15384	14677.44
15	26121	23832.29
16	6475	9946.458
17	6401	7110.092
18	6336	6490.818
19	6321	6354.964
20	5780	5894.993
21	11179	5894.993

22	19272	5894.993
23	6096	5894.993
24	4959	5894.993



HAULT WINTERS

m=HoltWinters(t,gamma=FALSE)

> m

Holt-Winters exponential smoothing with trend and without seasonal component.

Call:

HoltWinters(x = t, gamma = FALSE)

Smoothing parameters:

alpha: 0.7473972

beta : 0.082653

gamma: FALSE

Coefficients:

[,1]

a 5527.811

b -1439.695

Holt

Sr. No.	Observed	Expected
1	27182	

2	21917	
3	25417	16652
4	14664	18575.83
5	14308	10604.66
6	12580	8655.121
7	30187	7099.475
8	44536	21485.43
9	12548	37163.94
10	10108	15068.33
11	8832	7683.317
12	6727	5024.546
13	12998	2885.781
14	15384	7742.038
15	26121	11151.66
16	6475	21008.88
17	6401	7526.014
18	6336	4208.002
19	6321	3493.567
20	5780	3474.721
21	11179	3189.622
22	19272	1145.879
23	6096	-897.863
24	4959	-2941.61

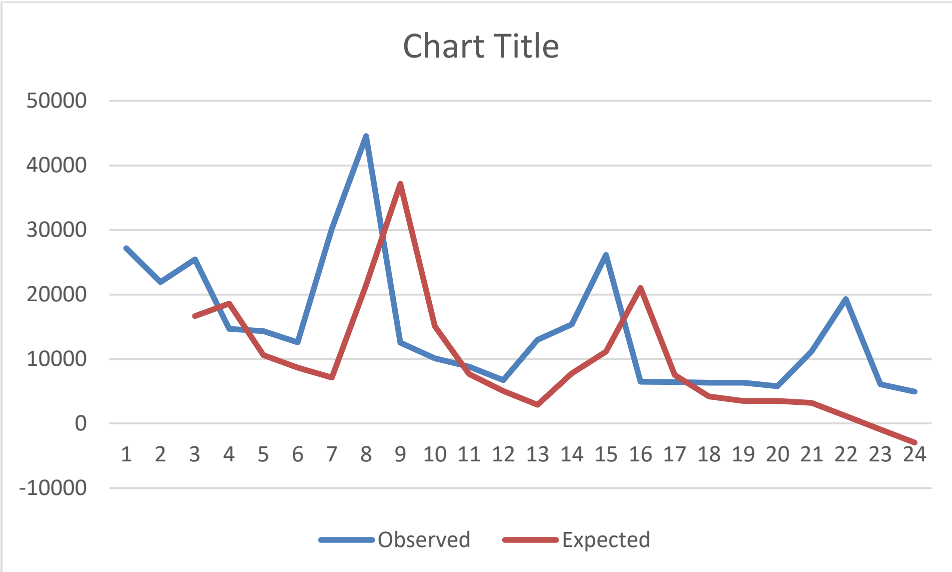
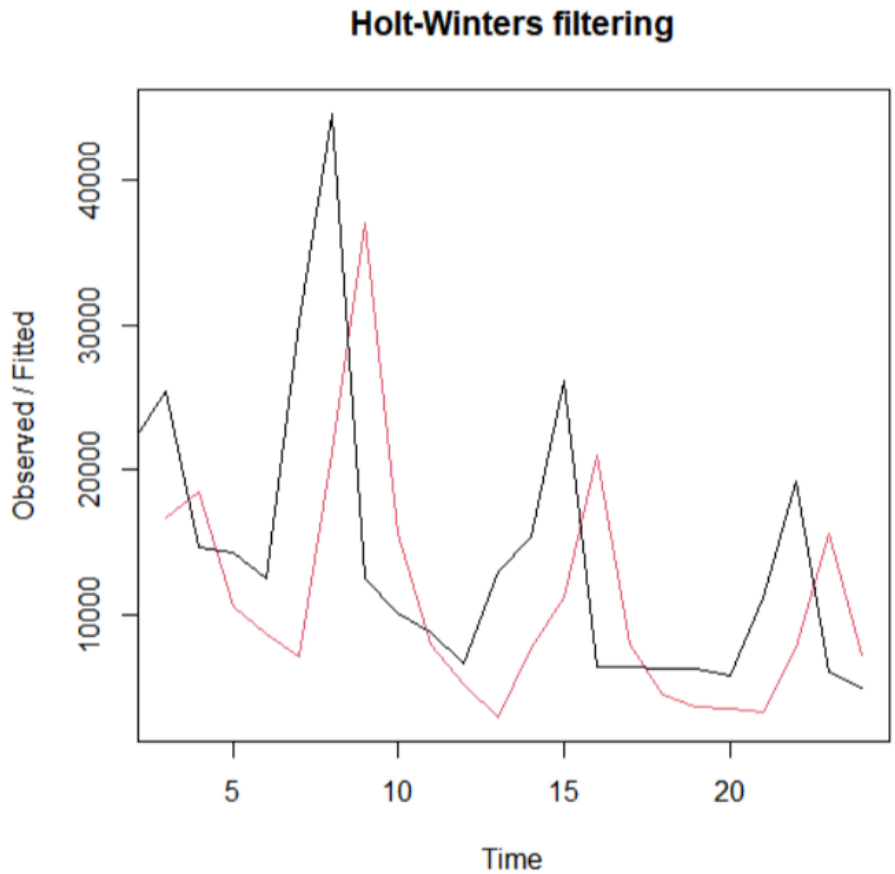


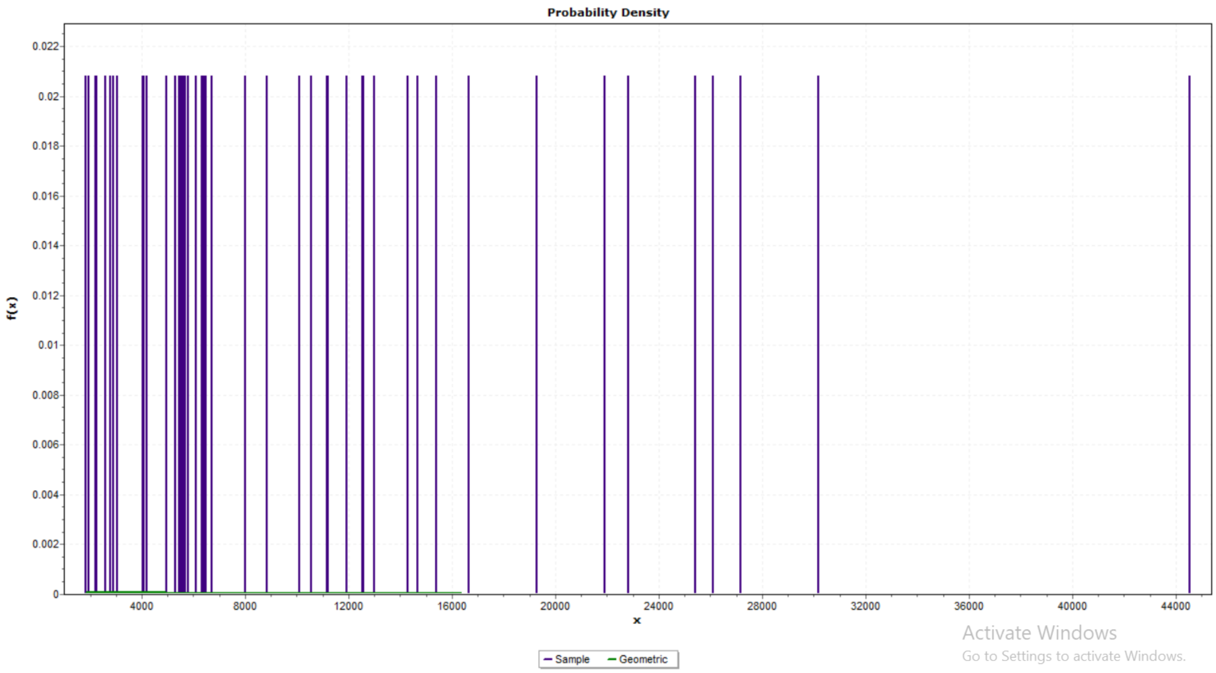
Chart Title
50000
40000
30000
20000
10000
0
-10000
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24
Observed
Expected



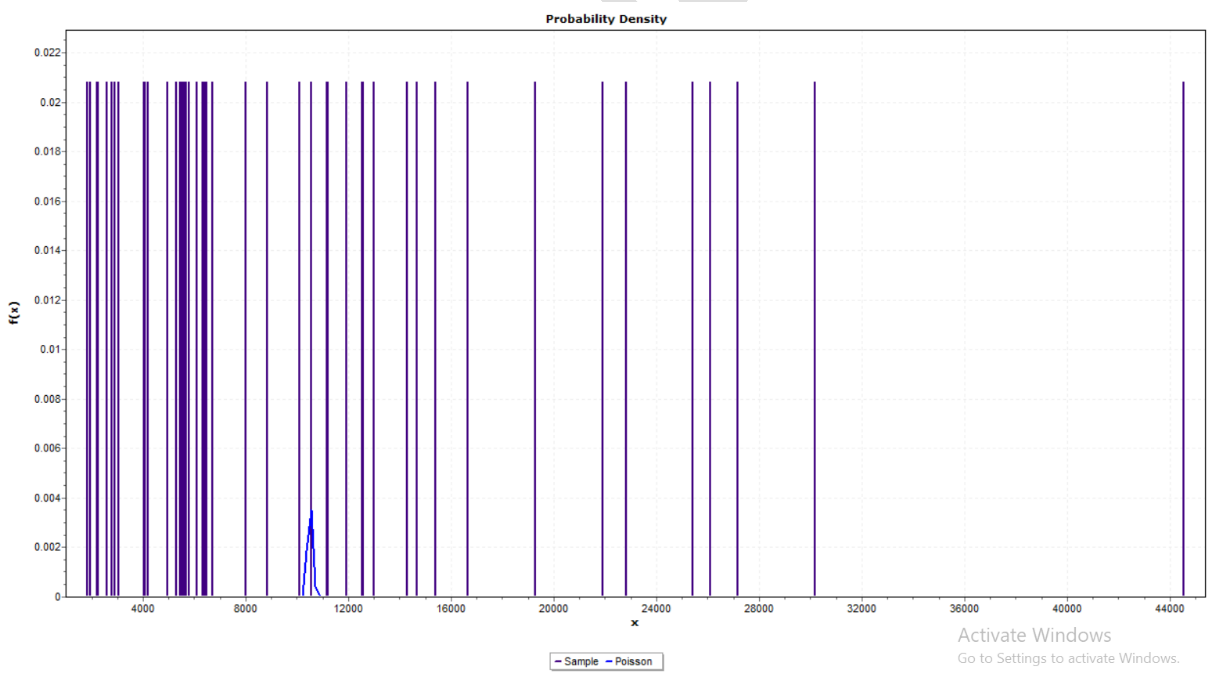
>

VANAZ AND PHUGEWADI

FITTED GRAPHS

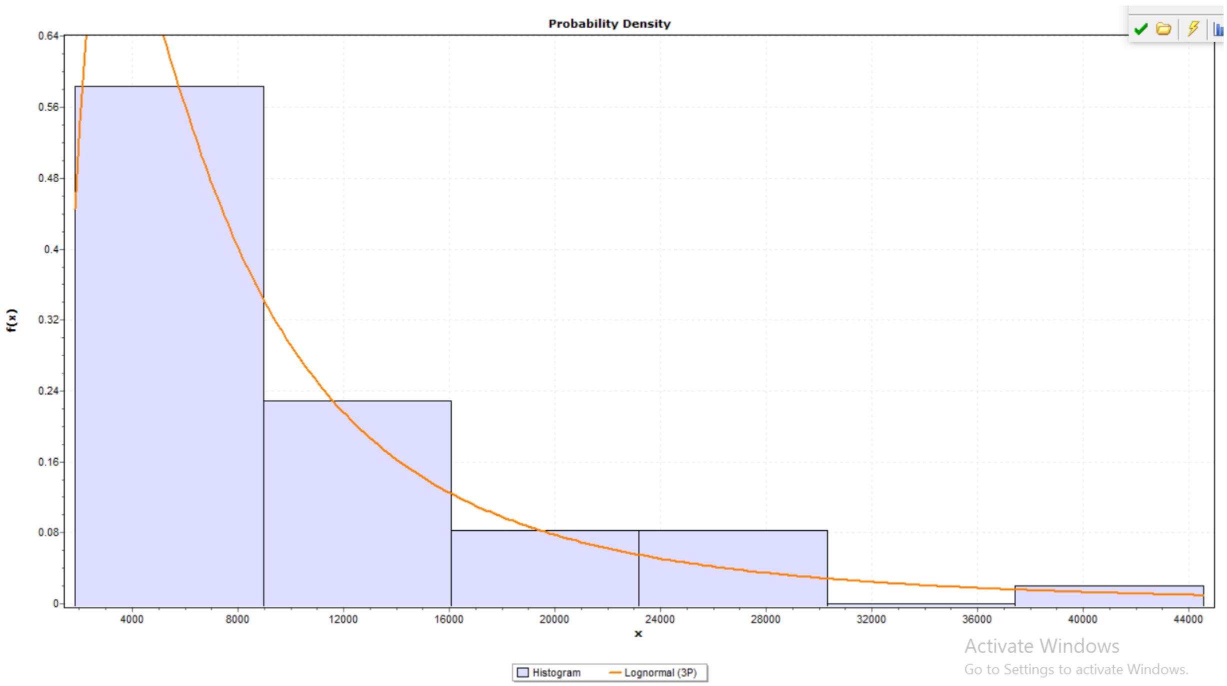


P=9.513E-05



LAMBDA:10511

CONTINOUS:



STATISTIC:0.070

AUTO REGRESSIVE

AR MODEL

AR (1) – $\mathbf{Y_t = a_1\, Y_{t-1} + a_2 Y_{t-2} + \ldots\ldots + a_k Y_{t-k} + b + \varepsilon}$

1. AR MODEL

	PHUGEWADI + VANAZ AR MODEL	
SR NO.	ORDER	AIC
1	arima(x = x, order = c(1, 0, 0))	aic = 1003.87
2	arima(x = x, order = c(2, 0, 0))	aic = 1005.68
3	arima(x = x, order = c(3, 0, 0))	aic = 1007.67
4	arima(x = x, order = c(4, 0, 0))	aic = 1009.19
5	arima(x = x, order = c(5, 0, 0))	aic = 1009.23
6	arima(x = x, order = c(6, 0, 0))	aic = 1011.01
7	arima(x = x, order = c(7, 0, 0))	aic = 1009.62
8	arima(x = x, order = c(8, 0, 0))	aic = 996.27
9	arima(x = x, order = c(9, 0, 0))	aic = 998.25
10	arima(x = x, order = c(10, 0, 0))	aic = 1000.25
11	arima(x = x, order = c(11, 0, 0))	aic = 998.29
12	arima(x = x, order = c(12, 0, 0))	aic = 1000.25
13	arima(x = x, order = c(13, 0, 0))	aic = 1002.24
14	arima(x = x, order = c(14, 0, 0))	aic = 1003.43
15	arima(x = x, order = c(15, 0, 0))	aic = 1004.89

optimum model :arima(b, order = c(8,0,0))

aic = 996.27

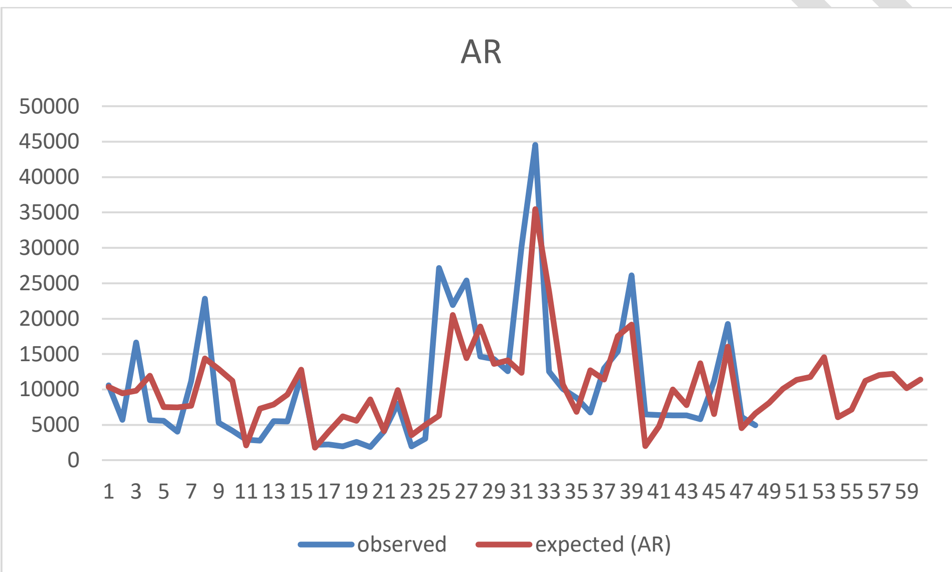
FITTED VALUES –

SR NO.	Observed	Expected (AR)	SPILTTED(AR)
1	10570	10359.637	10528.044
2	5688	9445.433	9447.034
3	16653	9814.158	10141.782
4	5659	11941.362	11772.053
5	5566	7500.335	7665.8
6	4038	7455.913	7596.93
7	11189	7674.165	7286.535
8	22814	14392.072	15302.09
9	5301	12885.156	12222.103
10	4182	11224.2	11159.41
11	2912	2096.347	2468.518
12	2775	7291.729	7171.704
13	5526	7867.776	9207.813
14	5461	9278.829	8634.526
15	11929	12784.566	12571.189
16	2200	1755.457	1475.836
17	2241	4050.373	3837.564

18	1964	6220.316	6864.28
19	2583	5568.201	5333.959
20	1849	8600.144	9358.201
21	4070	4119.626	3690.118
22	8023	9928.038	9951.88
23	1944	3555.123	3346.029
24	3057	4985.211	5057.201
25	27182	6309.202	6558.131
26	21917	20536.697	20534.998
27	25417	14430.79	14343.846
28	14664	18915.846	19472.435
29	14308	13594.1	12992.693
30	12580	14099.796	16159.67
31	30187	12366.158	12390.724
32	44536	35475.387	36448.255
33	12548	23885.566	22833.283
34	10108	10739.343	10729.95
35	8832	6829.238	7448.458
36	6727	12714.857	12920.367

37	12998	11412.02	13455.186
38	15384	17522.186	16312.669
39	26121	19166.336	18477.159
40	6475	2019.254	1524.079
41	6401	4802.866	4326.343
42	6336	9990.753	9951.999
43	6321	7762.423	9820.66
44	5780	13692.644	16282.938
45	11179	6534.266	11755.171
46	19272	16066.237	14443.411
47	6096	4543.128	3717.337
48	4959	6605.608	4900.074
49		8091.221	
50		10071.859	
51		11341.92	
52		11773.043	
53		14553.096	
54		6047.193	
55		7150.322	
56		11212.313	
57		12052.088	
58		12191.248	
59		10183.629	
60		11406.555	

GRAPH –

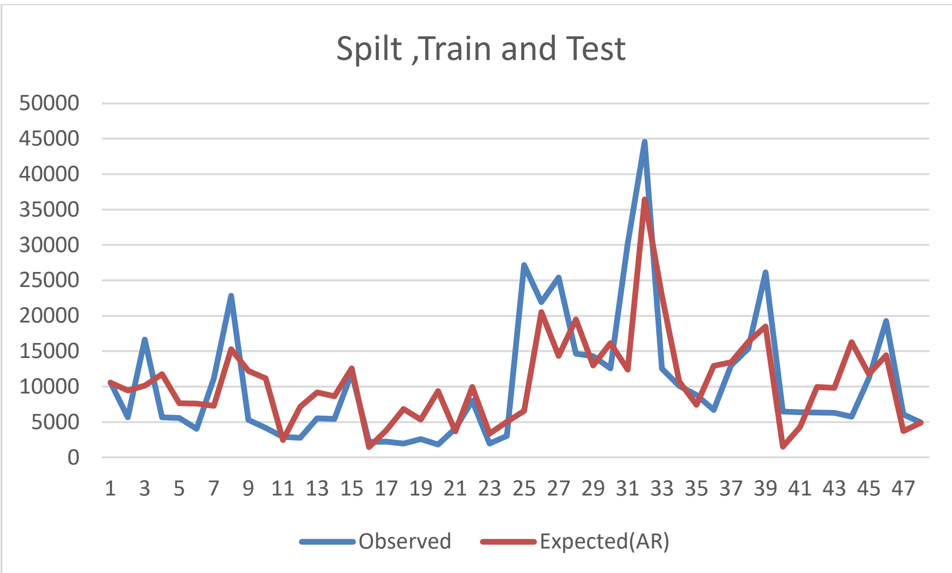


SPLIT N TEST –

Sr no.	Observed	Expected(AR)
1	10570	10528.044
2	5688	9447.034
3	16653	10141.782
4	5659	11772.053
5	5566	7665.8
6	4038	7596.93
7	11189	7286.535
8	22814	15302.09
9	5301	12222.103
10	4182	11159.41
11	2912	2468.518
12	2775	7171.704
13	5526	9207.813
14	5461	8634.526
15	11929	12571.189
16	2200	1475.836
17	2241	3837.564
18	1964	6864.28
19	2583	5333.959
20	1849	9358.201
21	4070	3690.118
22	8023	9951.88
23	1944	3346.029
24	3057	5057.201
25	27182	6558.131
26	21917	20534.998
27	25417	14343.846
28	14664	19472.435
29	14308	12992.693

30	12580	16159.67
31	30187	12390.724
32	44536	36448.255
33	12548	22833.283
34	10108	10729.95
35	8832	7448.458
36	6727	12920.367
37	12998	13455.186
38	15384	16312.669
39	26121	18477.159
40	6475	1524.079
41	6401	4326.343
42	6336	9951.999
43	6321	9820.66
44	5780	16282.938
45	11179	11755.171
46	19272	14443.411
47	6096	3717.337
48	4959	4900.074

GRAPH-



2. MA MODEL

MA (1) $= X_t = \mu + w_t + \theta_1 w_{t-1} + \theta_2 w_{t-2} + \ldots.. + \theta_q w_{t-q}$

	PHUGEWADI + VANAZ MA MODEL	
SR NO.	ORDER	AIC
1	arima(x = x, order = c(0, 0, 1))	aic = 1004.73
2	arima(x = x, order = c(0, 0, 2))	aic = 1005.65
3	arima(x = x, order = c(0, 0, 3))	aic = 1007.61
4	arima(x = x, order = c(0, 0, 4))	aic = 1008.84
5	arima(x = x, order = c(0, 0, 5))	aic = 1005.96
6	arima(x = x, order = c(0, 0, 6))	aic = 1007.24
7	arima(x = x, order = c(0, 0, 7))	aic = 1009.62
8	arima(x = x, order = c(0, 0, 8))	aic = 998.08
9	arima(x = x, order = c(0, 0, 9))	aic = 998.2
10	arima(x = x, order = c(0, 0, 10))	aic = 1000.01
11	arima(x = x, order = c(0, 0, 11))	aic = 1000.66
12	arima(x = x, order = c(0, 0, 12))	aic = 1000.91
13	arima(x = x, order = c(0, 0, 13))	aic = 1001.89
14	arima(x = x, order = c(0, 0, 14))	aic = 1002.93
15	arima(x = x, order = c(0, 0, 15))	aic = 1005.76

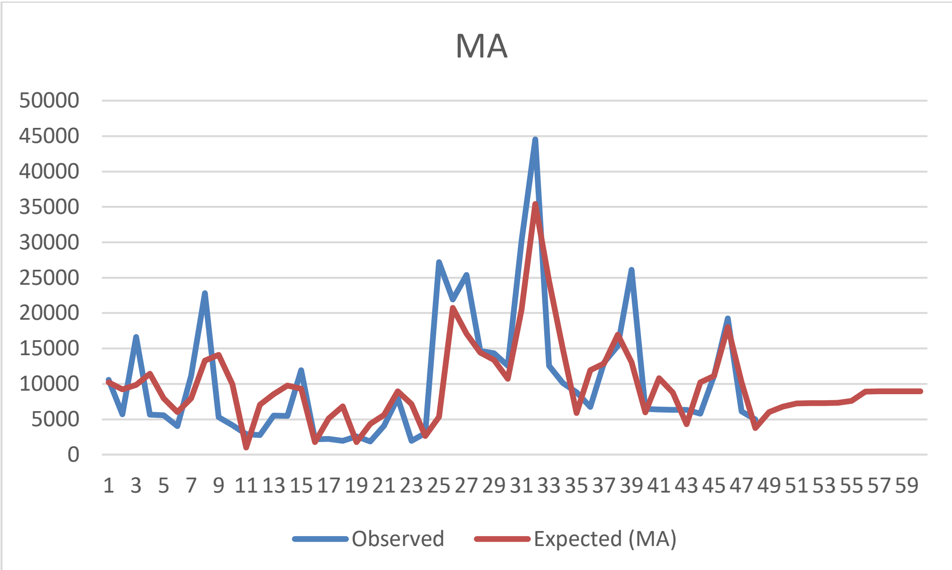
FITTED VALUES –

sr no	observed	expected (MA)
1	10570	10195.9342
2	5688	9227.9621
3	16653	9846.6769
4	5659	11437.3133
5	5566	7967.7526
6	4038	6011.6888
7	11189	7976.8119
8	22814	13279.2354
9	5301	14105.9878

10	4182	9933.9986
11	2912	988.2075
12	2775	7036.1392
13	5526	8564.8872
14	5461	9778.5342
15	11929	9319.578
16	2200	1755.0014
17	2241	5113.0684
18	1964	6827.3696
19	2583	1769.9243
20	1849	4360.0353
21	4070	5612.4332
22	8023	8937.7804
23	1944	7165.9544
24	3057	2643.7343
25	27182	5343.2033
26	21917	20748.5086
27	25417	17084.0427
28	14664	14432.3446
29	14308	13373.9676
30	12580	10735.5496
31	30187	20463.6755
32	44536	35443.5951
33	12548	24551.6732
34	10108	14950.9284
35	8832	5871.3094
36	6727	11946.5038
37	12998	12870.4712
38	15384	16949.7588
39	26121	13042.3899
40	6475	5990.0742

41	6401	10818.653
42	6336	8755.3401
43	6321	4301.8897
44	5780	10234.4122
45	11179	11102.1577
46	19272	18024.2328
47	6096	10209.2553
48	4959	3747.7375
49		6011.679
50		6791.907
51		72410274
52		7259.886
53		7288.524
54		7318.912
55		7590.838
56		8922.716
57		8941.784
58		8941.784
59		8941.784
60		8941.784

GRAPH –



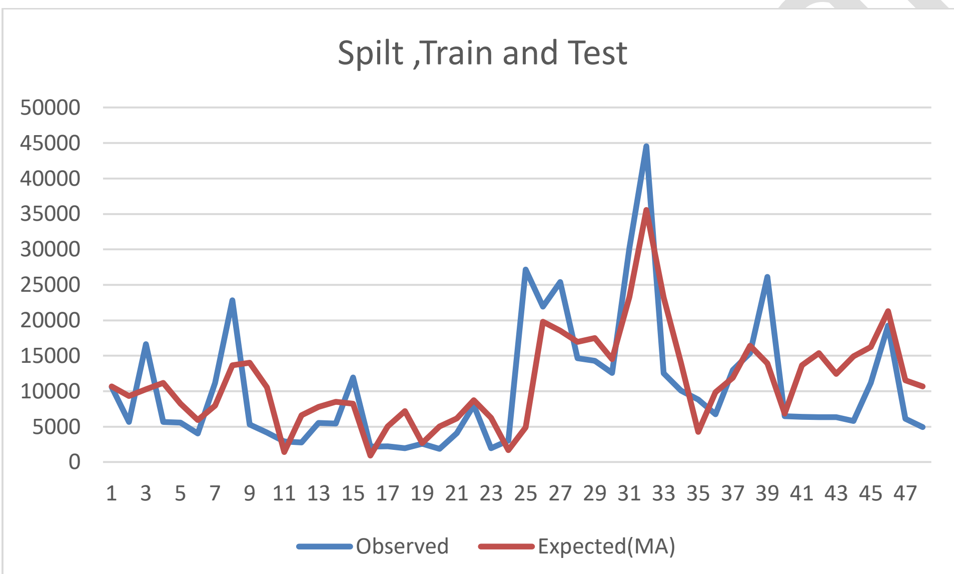
SPILT N TEST-

Sr no.	Observed	Expected(MA)
1	10570	10658.2381
2	5688	9309.114
3	16653	10277.0546
4	5659	11194.0361
5	5566	8233.8092
6	4038	5929.2727
7	11189	7966.409
8	22814	13641.0829
9	5301	14030.6882
10	4182	10546.663
11	2912	1403.0667
12	2775	6609.6837

13	5526	7810.3425
14	5461	8526.401
15	11929	8256.4665
16	2200	944.8941
17	2241	5024.6262
18	1964	7199.2504
19	2583	2687.2995
20	1849	5022.9949
21	4070	6143.7582
22	8023	8734.1638
23	1944	6253.9516
24	3057	1709.0344
25	27182	4912.6099
26	21917	19783.369
27	25417	18557.6662
28	14664	16939.0274
29	14308	17520.3918
30	12580	14526.1259
31	30187	23288.4637
32	44536	35565.507
33	12548	23218.3469
34	10108	14000.0955
35	8832	4242.7576
36	6727	9853.9624
37	12998	11883.1109
38	15384	16415.7495
39	26121	13931.4842
40	6475	6837.2084
41	6401	13657.26
42	6336	15359.48
43	6321	12438.87

44	5780	14911.5
45	11179	16237.4
46	19272	21296.61
47	6096	11520.47
48	4959	10689.62

GRAPH –



ARMA

Combine	
ARIMA Model	***AIC***
arima(x = t, order = c(1, 0, 8))	996.23
arima(x = t, order = c(2, 0, 8))	998.05
arima(x = t, order = c(3, 0, 9))	1000.73
arima(x = t, order = c(4, 0, 7))	1001.88
arima(x = t, order = c(5, 0, 5))	999.83
arima(x = t, order = c(6, 0, 4))	1001.77
arima(x = t, order = c(7, 0, 5))	999.19
arima(x = t, order = c(8, 0, 6))	997.28
arima(x = t, order = c(9, 0, 3))	997.47
arima(x = t, order = c(10, 0, 1))	999.19

Model Fitting-

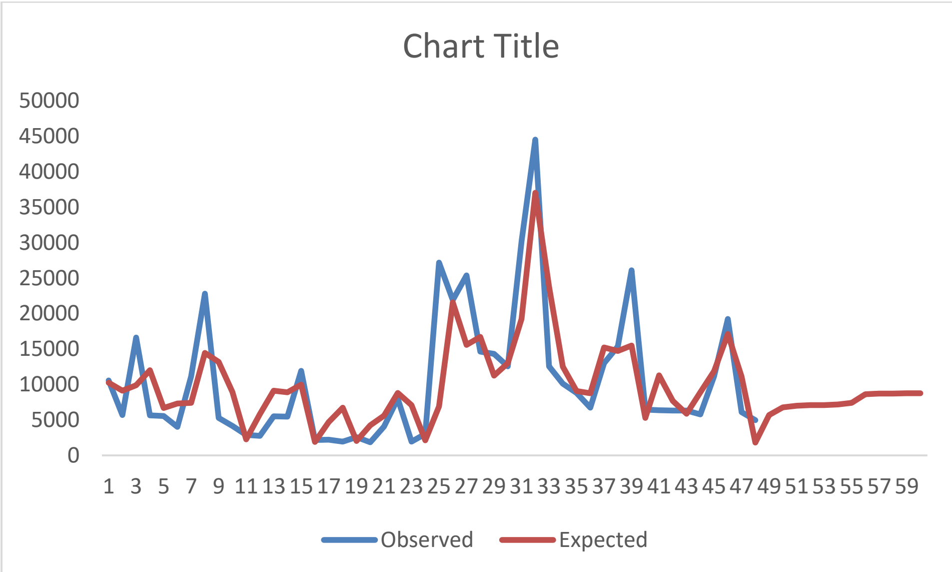
Model = arima(x = t, order = c(1, 0, 8))

AIC = 996.23

	Observed	Expected
1	10570	10267.12
2	5688	9128.026
3	16653	9899.133
4	5659	12043.98
5	5566	6674.91
6	4038	7343.237
7	11189	7423.188
8	22814	14459.86
9	5301	13198.15
10	4182	8940.344
11	2912	2247.893
12	2775	5821.912
13	5526	9111.64
14	5461	8911.215
15	11929	9990.49
16	2200	1910.146
17	2241	4725.145
18	1964	6758.108

19	2583	2031.347
20	1849	4262.307
21	4070	5591.026
22	8023	8821
23	1944	7100.89
24	3057	2112.839
25	27182	6934.709
26	21917	21580.03
27	25417	15589.26
28	14664	16734.69
29	14308	11238.45
30	12580	13024.08
31	30187	19229.74
32	44536	37066
33	12548	23796.94
34	10108	12512.82
35	8832	9085.262
36	6727	8768.417
37	12998	15247.02
38	15384	14740.98
39	26121	15516.82
40	6475	5279.884
41	6401	11283.91
42	6336	7699.722
43	6321	5875.599
44	5780	8905.324
45	11179	11867.45
46	19272	17131.43
47	6096	11110.18
48	4959	1828.836
49		5707.392
50		6784.68
51		7029.752
52		7102.948
53		7105.925
54		7172.792
55		7399.163
56		8659.193
57		8706.703
58		8736.899
59		8756.121
60		8768.37

#Graph-

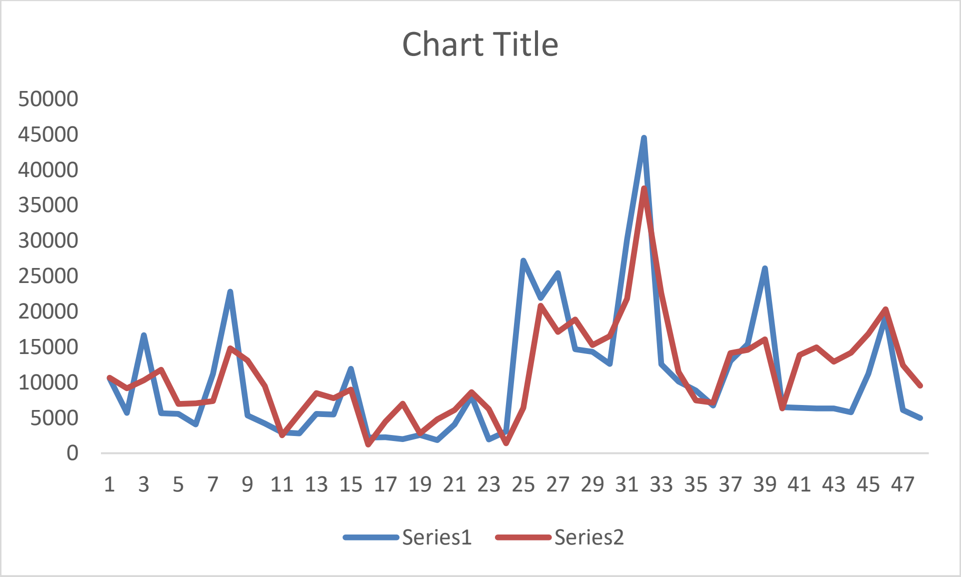


Split, Train and Test-

	b	d
1	10570	10657.55
2	5688	9182.658
3	16653	10306.2
4	5659	11786.83
5	5566	6942.823
6	4038	7052.726
7	11189	7346.989
8	22814	14789.9
9	5301	13093.76
10	4182	9457.497
11	2912	2541.036
12	2775	5549.657
13	5526	8483.718
14	5461	7751.273
15	11929	8966.178
16	2200	1212.179
17	2241	4455.19
18	1964	6988.739
19	2583	2783.233
20	1849	4768.763
21	4070	6069.673
22	8023	8601.256
23	1944	6228.834
24	3057	1370.791
25	27182	6413.089
26	21917	20833.88

27	25417	17111.84
28	14664	18874.04
29	14308	15254.08
30	12580	16541.44
31	30187	21793.06
32	44536	37386.59
33	12548	22595.06
34	10108	11483.51
35	8832	7446.41
36	6727	7132.421
37	12998	14140.83
38	15384	14561.83
39	26121	16092.55
40	6475	6305.696
41	6401	13867.92
42	6336	14929.08
43	6321	12912.3
44	5780	14196.74
45	11179	16827.38
46	19272	20309.44
47	6096	12434.52
48	4959	9508.574

#Graph-



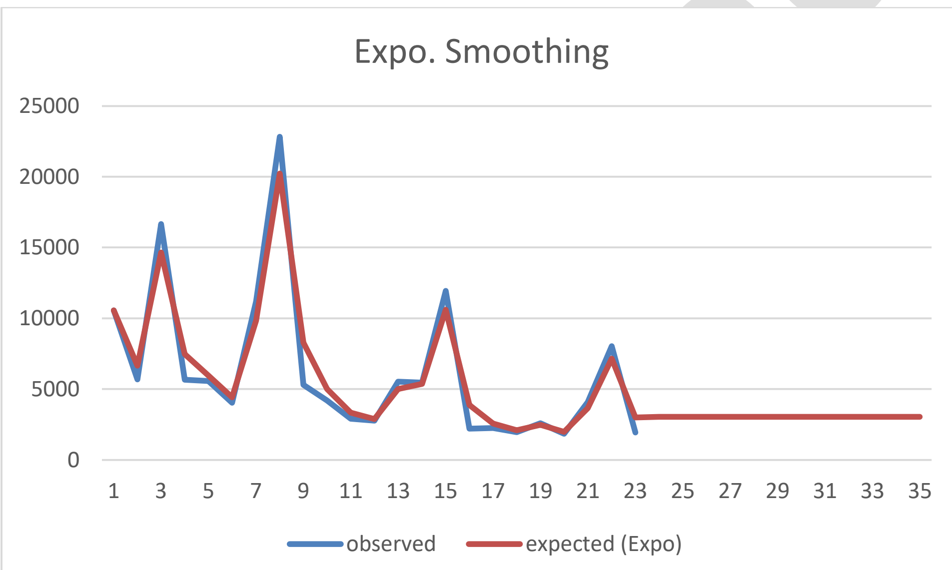
3. EXPONENTIAL MODEL-

FITTED VALUES-

Sr no.	Observed	Expected (Expo)
1	10570	10570
2	5688	6664.4
3	16653	14655.28
4	5659	7458.256
5	5566	5944.451
6	4038	4419.29
7	11189	9835.058
8	22814	20218.212
9	5301	8284.442
10	4182	5002.488
11	2912	3330.098
12	2775	2886.02
13	5526	4998.004
14	5461	5368.401
15	11929	10616.88
16	2200	3883.376
17	2241	2569.475
18	1964	2085.095
19	2583	2483.419
20	1849	1975.884
21	4070	3651.177
22	8023	7148.635
23	1944	2984.927
24		3042.585
25		3042.585

26		3042.585
27		3042.585
28		3042.585
29		3042.585
30		3042.585
31		3042.585
32		3042.585
33		3042.585
34		3042.585
35		3042.585

GRAPH-

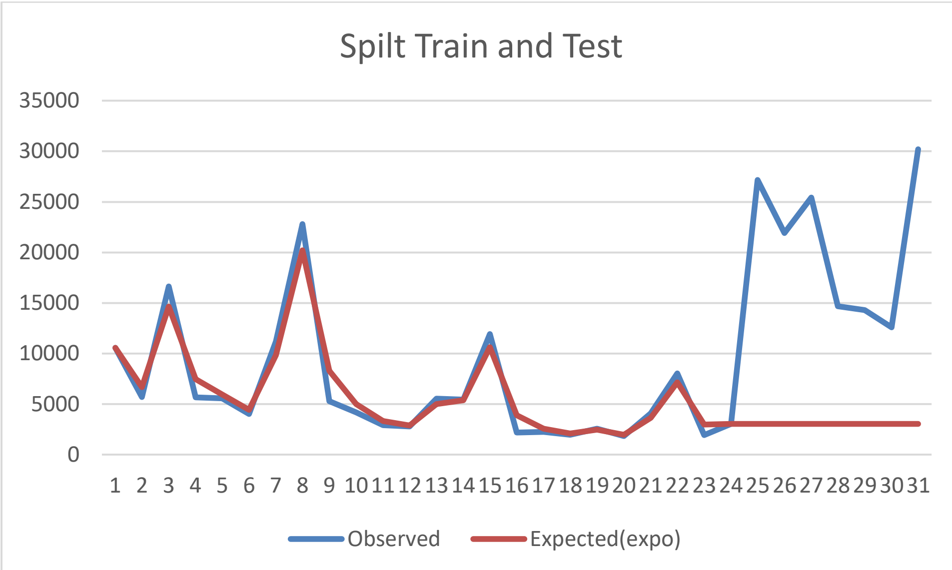


SPILT N TEST-

Sr no.	Observed	Expected(expo)
1	10570	10570
2	5688	6664.4

3	16653	14655.28
4	5659	7458.256
5	5566	5944.451
6	4038	4419.29
7	11189	9835.058
8	22814	20218.212
9	5301	8284.442
10	4182	5002.488
11	2912	3330.098
12	2775	2886.02
13	5526	4998.004
14	5461	5368.401
15	11929	10616.88
16	2200	3883.376
17	2241	2569.475
18	1964	2085.095
19	2583	2483.419
20	1849	1975.884
21	4070	3651.177
22	8023	7148.635
23	1944	2984.927
24	3057	3042.585
25	27182	3042.585
26	21917	3042.585
27	25417	3042.585
28	14664	3042.585
29	14308	3042.585
30	12580	3042.585
31	30187	3042.585

GRAPH –



4. HOLTWINTERS MODEL –

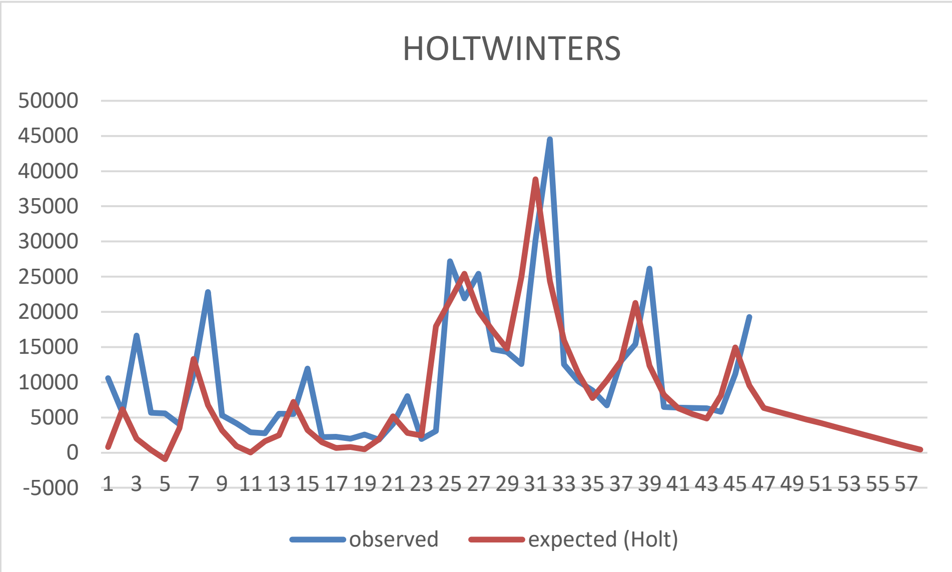
FITTED VALUES-

Sr no.	observed	expected (Holt)
1	10570	806
2	5688	6158.1551
3	16653	1974.9836
4	5659	401.121
5	5566	-911.7163
6	4038	3475.8415
7	11189	13317.1894
8	22814	6738.9787
9	5301	3169.8154

10	4182	920.7024
11	2912	18.9999
12	2775	1595.7419
13	5526	2467.1037
14	5461	7201.9109
15	11929	3205.572
16	2200	1494.2625
17	2241	647.0874
18	1964	777.0533
19	2583	473.8122
20	1849	1869.8287
21	4070	5148.9113
22	8023	2780.9614
23	1944	2454.5187
24	3057	17936.8565
25	27182	21613.801
26	21917	25432.9553
27	25417	20086.3428
28	14664	17268.7625
29	14308	14782.4853
30	12580	24970.5066
31	30187	38838.4046
32	44536	24352.9028
33	12548	15952.3439
34	10108	11234.95
35	8832	7745.8287
36	6727	10269.3994
37	12998	13042.5779
38	15384	21288.4612
39	26121	12364.2598
40	6475	8201.0229

41	6401	6300.1943
42	6336	5497.0702
43	6321	4864.5692
44	5780	8145.5056
45	11179	14941.0268
46	19272	9555.7312
47		6344.0509
48		5804.7713
49		5265.4917
50		4726.212
51		4186.9324
52		3647.6528
53		3108.3731
54		2569.0935
55		2029.8139
56		1490.5343
57		951.2546
58		411.975

GRAPH –



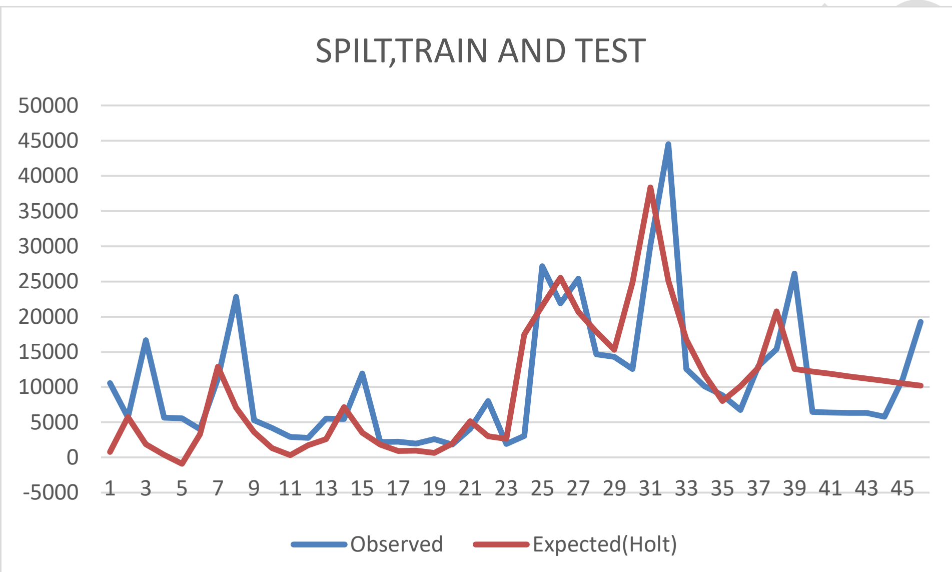
SPILT N TEST –

Sr no.	Observed	Expected(Holt)
1	10570	806
2	5688	5732.955
3	16653	1886.6099
4	5659	358.4585
5	5566	-918.5102
6	4038	3272.3534
7	11189	12891.0299
8	22814	7049.339
9	5301	3612.934

10	4182	1321.8145
11	2912	316.2158
12	2775	1735.0399
13	5526	2590.9348
14	5461	7174.8701
15	11929	3536.6523
16	2200	1836.2966
17	2241	928.5498
18	1964	974.5414
19	2583	650.6379
20	1849	1961.6502
21	4070	5141.3407
22	8023	3003.7382
23	1944	2659.9962
24	3057	17465.5183
25	27182	21521.2466
26	21917	25536.7691
27	25417	20676.7453
28	14664	17862.6364
29	14308	15286.1896
30	12580	24842.368
31	30187	38382.0623
32	44536	25085.0184
33	12548	16745.2842
34	10108	11755.7887
35	8832	8011.7158
36	6727	10123.5846
37	12998	12745.409
38	15384	20749.3354
39	26121	12551.32
40	6475	12214.71

41	6401	11878.1
42	6336	11541.49
43	6321	11204.88
44	5780	10868.27
45	11179	10531.66
46	19272	10195.05

GRAPH-



Statistical Techniques Used:

- Time Series
- Model fitting
- Kolmogorov-Smirnov Test
- Mann-Kendall Test

Softwares Used:

- Excel
- R
- Easy Fit

CONCLUSION

This study has discussed the application of test series about "Pune Metro". From the result obtained that there is a decreasing number of passengers.

· According to the data study it is observed that there is a increase in number of passengers on weekends.

· The best fitted model according to the study is

Phugewadi - ARMA

Vanaz - AR

Pune - AR

· So from the analysis there is a need to increase awareness among people about metro and its usage.

LIMITATIONS :

The only limitation of this project is that there are only two station's information data is available

REPORT ISSUED BY TIMES OF INDIA

TIMES CITY | PUNE

Metro ridership dips in second month but train frequency to remain same

From 20,600 In March To 7,600 Daily In April, In Both Functional Corridors

Sarang.Dastane
@timesgroup.com

Pune: The Metro ridership has declined in the second month of service but MahaMetro said train operations will continue at the existing frequency of 30 minutes and there was no plan to extend it beyond half-an-hour.

The daily average ridership on both routes — PCMC to Phugewadi and Vanaz to Garware College — remained around 20,600 in March but in April it dropped to 7,600 daily.

MahaMetro officials said though there has been a decline in ridership, it may go up from June as colleges and educational institutions reopen.

"We have observed that students are travelling in the Metro particularly on the Garware College route but numbers are not huge. When the educational institutions reopen, we expect more citizens to use the service," said an official with the MahaMetro.

The total ridership has touched 8 lakh so far with a daily average of 13,600 commuters. Out of these over 5.65 lakh commuters have travelled on the Vanaz-Garware College route and 2.3 lakh on the PCMC-Phugewadi route so far, the MahaMetro said.

Hemant Sonawane, the general manager (PR) of MahaMetro, said, "The footfall will go up once the services are extended to Deccan Gymkhana, Jungli Maharaj Road, Shivajinagar on the Vanaz-Civil Court route. Works have also been expedited on Phugewadi to Range Hills section so that it could be linked to Vanaz line."

A few daily commuters said that the Metro will benefit only if the services are extended till an interchanging station at Civil Court.

METRO TARGETS

Overall progress: 72% work completed

- Work up to Civil Court: **By July 2022**
- Ridership in two months: **Around 8 lakh**
- Average ridership: **13,700**

"Initially, many people took the ride to get a feel of the Metro services. It was expected that the footfall may go down after the initial days. We are working towards the extension of services up to the Civil Court. The footfall will go up once the services are extended

Hemant Sonawane | GENERAL MANAGER (PR) OF MAHAMETRO

DPR of Metro-neo service in PMC, PCMC areas in final stage

Pune: MahaMetro's ongoing study on a proposal to introduce Metro-neo service on the high capacity mass transit route in Pune and Pimpri Chinchwad is in the final stage.

MahaMetro is likely to make a presentation with the detailed project report (DPR) to the Pune and Pimpri Chinchwad municipal corporations soon. A source from the Pune Municipal Corporation (PMC) said the call on the execution of the Metro-neo project would be taken after examining the recommendation of DPR. MahaMetro had started the study of the proposal last year. The officials said it had been expedited and all technical aspects were being considered in it. TNN

THANK YOU