Great Lakes

Timeseries Forecasting

Australian Gas Production

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1. Project Objective

This project is to analyse Australian Monthly Gas production dataset “GAS” in package “FORECAST”. This is Time series data for Australian monthly gas production between 1956 - Jan to 1995 - August Objective is to use analyse and build a time series model to forecast 12 periods in future

2. Assumptions

There are a few assumptions considered.

- Sample size is adequate to perform techniques applicable for time series dataset.
- The Australian Gas Production time series data was downloaded from ‘FORECAST’ Package in R
- Components of Time series are not known
- Stationarity of Time series are not known
- Seasonality of Time series are not known

3. Exploratory Analysis of the Data

```
Library(ggplot12)

Library(tseries)

## Registered S3 method overwritten by 'xts':

##   method     from

##   as.zoo.xts zoo

## Registered S3 method overwritten by 'quantmod':

##   method            from

##   as.zoo.data.frame zoo

Library(forecast)

## Registered S3 methods overwritten by 'forecast':

##   method             from

##   fitted.fracdiff    fracdiff

##   residuals.fracdiff fracdiff

Library(kablextra)
```

Exploratory data analysis is an approach to analyse the datasets to summarize their main characteristics, often with visual methods.

```
data<-forecast::gas
print(data)
```

```
Jan  Feb  Mar  Apr  May  Jun  Jul  Aug  Sep  Oct  Nov  Dec
1956  1709  1646  1794  1878  2173  2321  2468  2416  2184  2121  1962  1825
1957  1751  1688  1920  1941  2311  2279  2638  2448  2279  2163  1941  1878
1958  1773  1688  1783  1984  2290  2511  2712  2522  2342  2195  1931  1910
1959  1730  1688  1899  1994  2342  2553  2712  2627  2363  2311  2026  1910
1960  1762  1815  2005  2089  2617  2828  2965  2891  2532  2363  2216  2026
1961  1804  1773  2015  2089  2627  2712  3007  2880  2490  2237  2205  1984
1962  1868  1815  2047  2142  2743  2775  3028  2965  2501  2501  2131  2015
1963  1910  1868  2121  2268  2690  2933  3218  3028  2659  2406  2258  2057
1964  1889  1984  2110  2311  2785  3039  3229  3070  2659  2543  2237  2142
1965  1962  1910  2216  2437  2817  3123  3345  3112  2659  2469  2332  2110
1966  1910  1941  2216  2342  2923  3229  3513  3355  2849  2680  2395  2205
1967  1994  1952  2290  2395  2965  3239  3608  3524  3018  2648  2363  2247
1968  1994  1941  2258  2332  3323  3608  3957  3672  3155  2933  2585  2384
1969  2057  2100  2458  2638  3292  3724  4652  4379  4231  3756  3429  3461
1970  3345  4220  4874  5064  5951  6774  7997  7523  7438  6879  6489  6288
1971  5919  6183  6594  6489  8040  9715  9714  9756  8595  7861  7753  8154
1972  7778  7402  8903  9742 11372 12741 13733 13691 12239 12502 11241 10829
1973 11569 10397 12493 11962 13974 14945 16805 16587 14225 14157 13016 12253
1974 11704 12275 13695 14082 16555 17339 17777 17592 16194 15336 14208 13116
1975 12354 12682 14141 14989 16159 18276 19157 18737 17109 17094 15418 14312
1976 13260 14990 15975 16770 19819 20983 22001 22337 20750 19969 17293 16498
1977 15117 16058 18137 18471 21398 23854 26025 25479 22804 19619 19627 18488
1978 17243 18284 20226 20903 23768 26323 28038 26776 22886 22813 22404 19795
1979 18839 18892 20823 22212 25076 26884 30611 30228 26762 25885 23328 21930
1980 21433 22369 24503 25905 30605 34984 37060 34502 31793 29275 28305 25248
1981 27730 27424 32684 31366 37459 41060 43558 42398 33827 34962 33480 32445
1982 30715 30400 31451 31306 40592 44133 47387 41310 37913 34355 34607 28729
1983 26138 30745 35018 34549 40980 42869 45022 40387 38180 38608 35308 30234
1984 28801 33034 35294 33181 40797 42355 46098 42430 41851 39331 37328 34514
1985 32494 33308 36805 34221 41020 44350 46173 44435 40943 39269 35901 32142
1986 31239 32261 34951 38109 43168 45547 49568 45387 41805 41281 36068 34879
1987 32791 34206 39128 40249 43519 46137 56709 52306 49397 45500 39857 37958
1988 35567 37696 42319 39137 47062 50610 54457 54435 48516 43225 42155 39995
1989 37541 37277 41778 41666 49616 57793 61884 62400 50820 51116 45731 42528
1990 40459 40295 44147 42697 52561 56572 56858 58363 45627 45622 41304 36016
1991 35592 35677 39864 41761 50380 49129 55066 55671 49058 44503 42145 38698
1992 38963 38690 39792 42545 50145 58164 59035 59408 55988 47321 42269 39606
1993 37059 37963 31043 41712 50366 56977 56807 54634 51367 48073 46251 43736
1994 39975 40478 46895 46147 55011 57799 62450 63896 57784 53231 50354 38410
1995 41600 41471 46287 49013 56624 61739 66600 60054
```

```
AU.gas=ts(data,start = c(1956,1),frequency = 12)
head(AU.gas)
```

```
      Jan  Feb  Mar  Apr  May  Jun
1956 1709 1646 1794 1878 2173 2321
```

tail(AU.gas)

```
       Mar   Apr   May   Jun   Jul   Aug
1995 46287 49013 56624 61739 66600 60054
```

Checking the class of dataset

class(AU.gas)

```
[1] "ts"
```

This time series has total of 476 entries with monthly frequency

Checking any Missing Values

any(is.na(AU.gas))

```
[1] FALSE
```

start(AU.gas)

```
[1] 1956    1
```

end(AU.gas)

```
[1] 1995    8
```

frequency(AU.gas)

```
[1] 12
```

summary(AU.gas)

```
   Min. 1st Qu.  Median    Mean 3rd Qu.    Max. 
   1646    2675   16788   21415   38629   66600 
```

cycle(AU.gas)

```
     Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
1956   1   2   3   4   5   6   7   8   9  10  11  12
1957   1   2   3   4   5   6   7   8   9  10  11  12
1958   1   2   3   4   5   6   7   8   9  10  11  12
1959   1   2   3   4   5   6   7   8   9  10  11  12
```

1960	1	2	3	4	5	6	7	8	9	10	11	12
1961	1	2	3	4	5	6	7	8	9	10	11	12
1962	1	2	3	4	5	6	7	8	9	10	11	12
1963	1	2	3	4	5	6	7	8	9	10	11	12
1964	1	2	3	4	5	6	7	8	9	10	11	12
1965	1	2	3	4	5	6	7	8	9	10	11	12
1966	1	2	3	4	5	6	7	8	9	10	11	12
1967	1	2	3	4	5	6	7	8	9	10	11	12
1968	1	2	3	4	5	6	7	8	9	10	11	12
1969	1	2	3	4	5	6	7	8	9	10	11	12
1970	1	2	3	4	5	6	7	8	9	10	11	12
1971	1	2	3	4	5	6	7	8	9	10	11	12
1972	1	2	3	4	5	6	7	8	9	10	11	12
1973	1	2	3	4	5	6	7	8	9	10	11	12
1974	1	2	3	4	5	6	7	8	9	10	11	12
1975	1	2	3	4	5	6	7	8	9	10	11	12
1976	1	2	3	4	5	6	7	8	9	10	11	12
1977	1	2	3	4	5	6	7	8	9	10	11	12
1978	1	2	3	4	5	6	7	8	9	10	11	12
1979	1	2	3	4	5	6	7	8	9	10	11	12
1980	1	2	3	4	5	6	7	8	9	10	11	12
1981	1	2	3	4	5	6	7	8	9	10	11	12
1982	1	2	3	4	5	6	7	8	9	10	11	12
1983	1	2	3	4	5	6	7	8	9	10	11	12
1984	1	2	3	4	5	6	7	8	9	10	11	12
1985	1	2	3	4	5	6	7	8	9	10	11	12
1986	1	2	3	4	5	6	7	8	9	10	11	12
1987	1	2	3	4	5	6	7	8	9	10	11	12
1988	1	2	3	4	5	6	7	8	9	10	11	12
1989	1	2	3	4	5	6	7	8	9	10	11	12
1990	1	2	3	4	5	6	7	8	9	10	11	12
1991	1	2	3	4	5	6	7	8	9	10	11	12
1992	1	2	3	4	5	6	7	8	9	10	11	12
1993	1	2	3	4	5	6	7	8	9	10	11	12
1994	1	2	3	4	5	6	7	8	9	10	11	12
1995	1	2	3	4	5	6	7	8				

```
AU.gas.qtr=aggregate(AU.gas,nfrequency = 4)
AU.gas.yrly=aggregate(AU.gas,nfrequency = 1)

AU.gas.qtr
```

	Qtr1	Qtr2	Qtr3	Qtr4
1956	5149	6372	7068	5908
1957	5359	6531	7365	5982
1958	5244	6785	7576	6036
1959	5317	6889	7702	6247
1960	5582	7534	8388	6605

```
1961   5592   7428   8377   6426
1962   5730   7660   8494   6647
1963   5899   7891   8905   6721
1964   5983   8135   8958   6922
1965   6088   8377   9116   6911
1966   6067   8494   9717   7280
1967   6236   8599  10150   7258
1968   6193   9263  10784   7902
1969   6615   9654  13262  10646
1970  12439  17789  22958  19656
1971  18696  24244  28065  23768
1972  24083  33855  39663  34572
1973  34459  40881  47617  39426
1974  37674  47976  51563  42660
1975  39177  49424  55003  46824
1976  44225  57572  65088  53760
1977  49312  63723  74308  57734
1978  55753  70994  77700  65012
1979  58554  74172  87601  71143
1980  68305  91494 103355  82828
1981  87838 109885 119783 100887
1982  92566 116031 126610  97691
1983  91901 118398 123589 104150
1984  97129 116333 130379 111173
1985 102607 119591 131551 107312
1986  98451 126824 136760 112228
1987 106125 129905 158412 123315
1988 115582 136809 157408 125375
1989 116596 149075 175104 139375
1990 124901 151830 160848 122942
1991 111133 141270 159795 125346
1992 117445 150854 174431 129196
1993 106065 149055 162808 138060
1994 127348 158957 184130 141995
1995 129358 167376
```

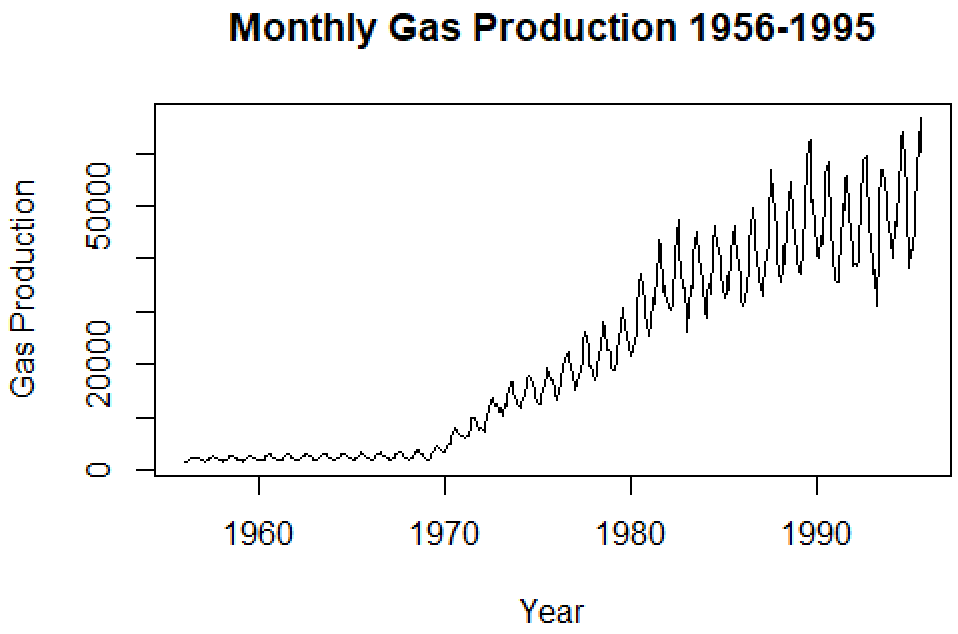
AU.gas.yrly

```
Time Series:
Start = 1956
End = 1994
Frequency = 1
 [1]  24497  25237  25641  26155  28109  27823  28531  29416  29998
30492  31558  32243  34142  40177
```

[15] 72842 94773 132173 162383 179873 190428 220645 245077 269459 291470 345982 418393 432898 438038
[29] 455014 461061 474263 517757 535174 580150 560521 537544 571926 555988 612430

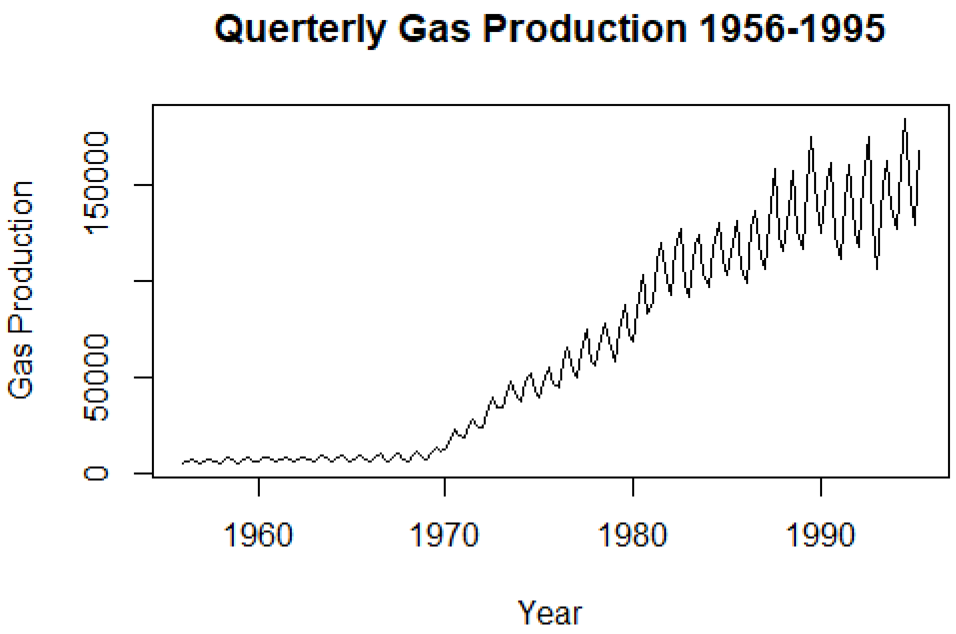
Plotting Methods

```
plot.ts(AU.gas,main="Monthly Gas Production 1956-1995",xlab="Year", ylab="Gas Production")
```

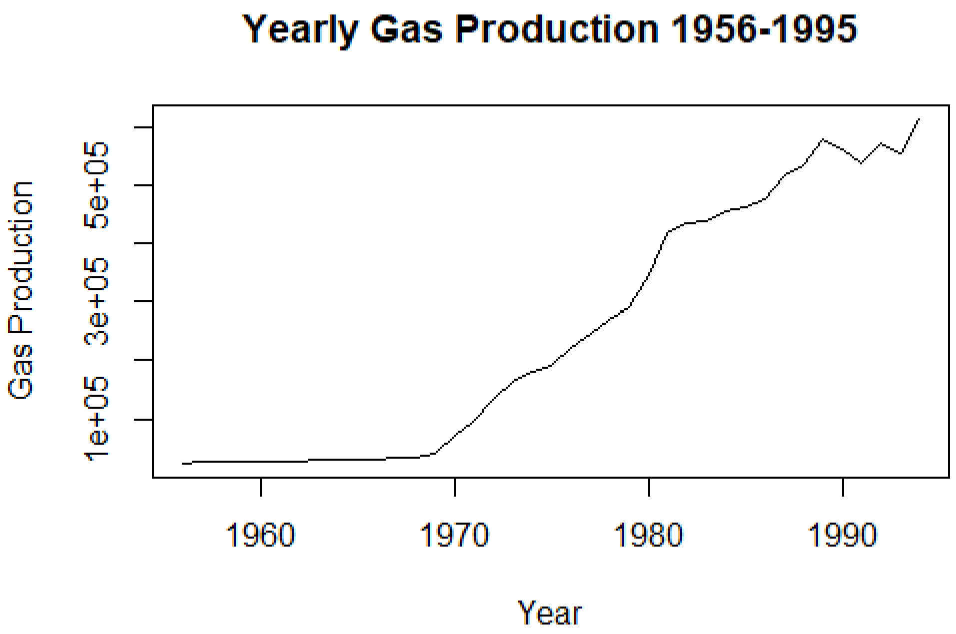


1. We observe that Monthly gas production between 1956 to almost 1970 is flattened level
2. Post 1970 era there is gradual increase in production i.e showing an upward trend with peaks and troughs indicating some seasonality in data

```
plot.ts(AU.gas.qtr,main="Querterly Gas Production 1956-1995",xlab="Year", ylab="Gas Production")
```

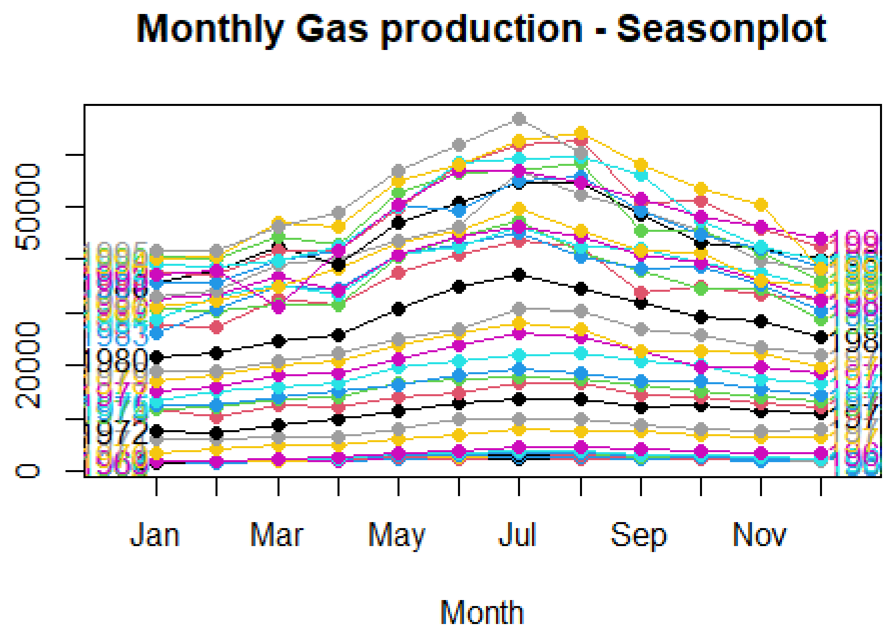



```
plot.ts(AU.gas.yrly,main="Yearly Gas Production 1956-1995",xlab="Year", ylab="Gas Production")
```

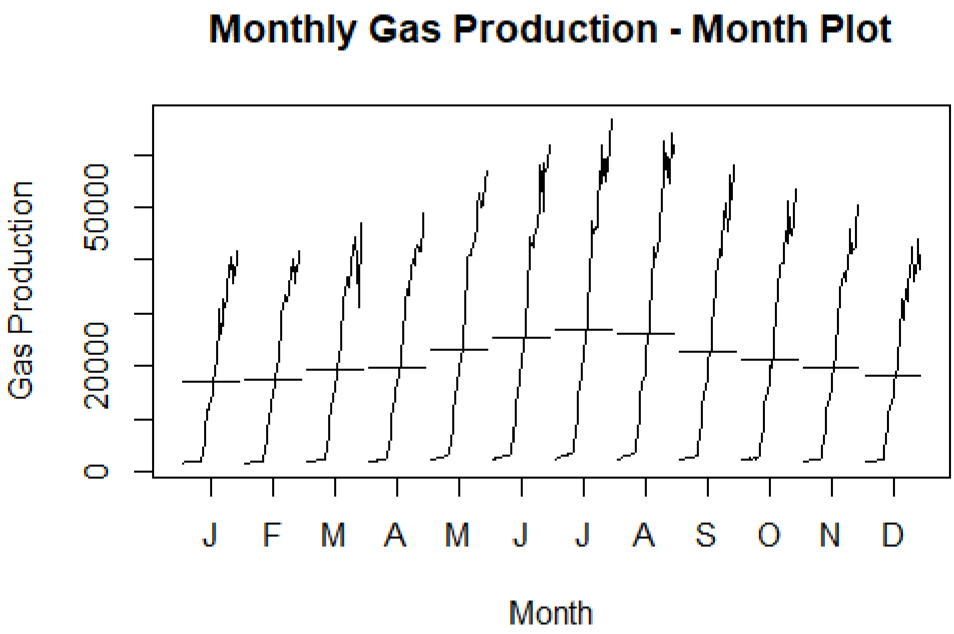


Seasonality Plot

```
seasonplot(AU.gas, year.labels = TRUE, year.labels.left = TRUE,col =
1:40, pch=19,main = "Monthly Gas production - Seasonplot")
```

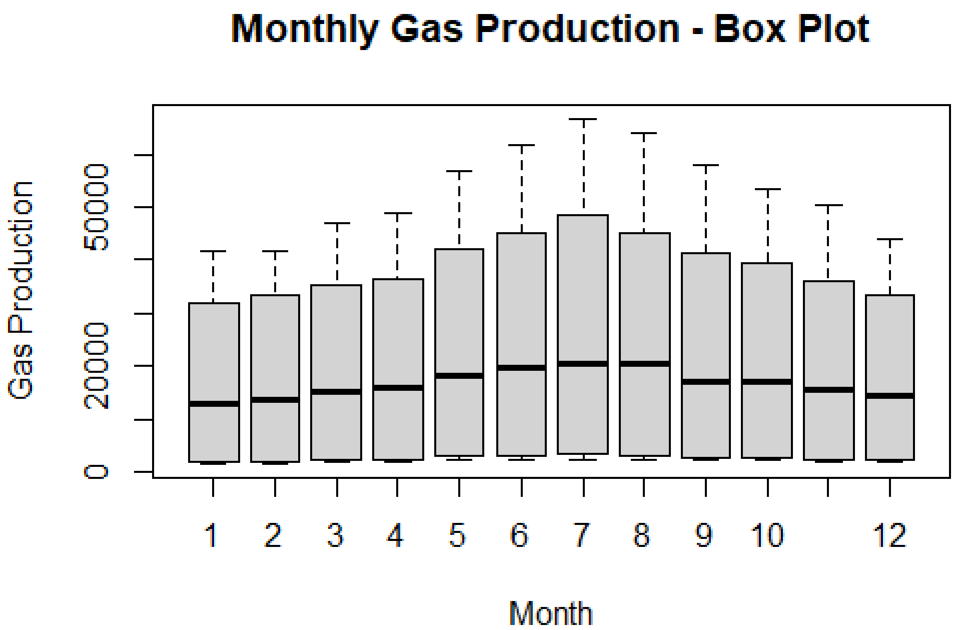



```
monthplot(AU.gas,main="Monthly Gas Production - Month
Plot",xlab="Month", ylab= "Gas Production")
```



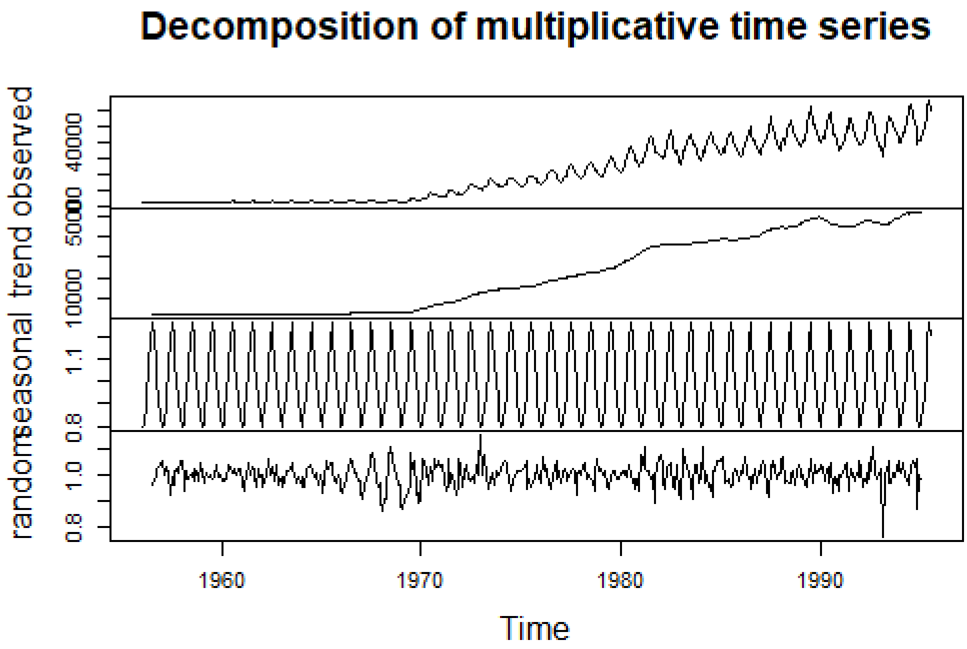
Boxplot

```
boxplot(AU.gas~cycle(AU.gas), main = "Monthly Gas Production - Box Plot", xlab = "Month" , ylab = "Gas Production")
```

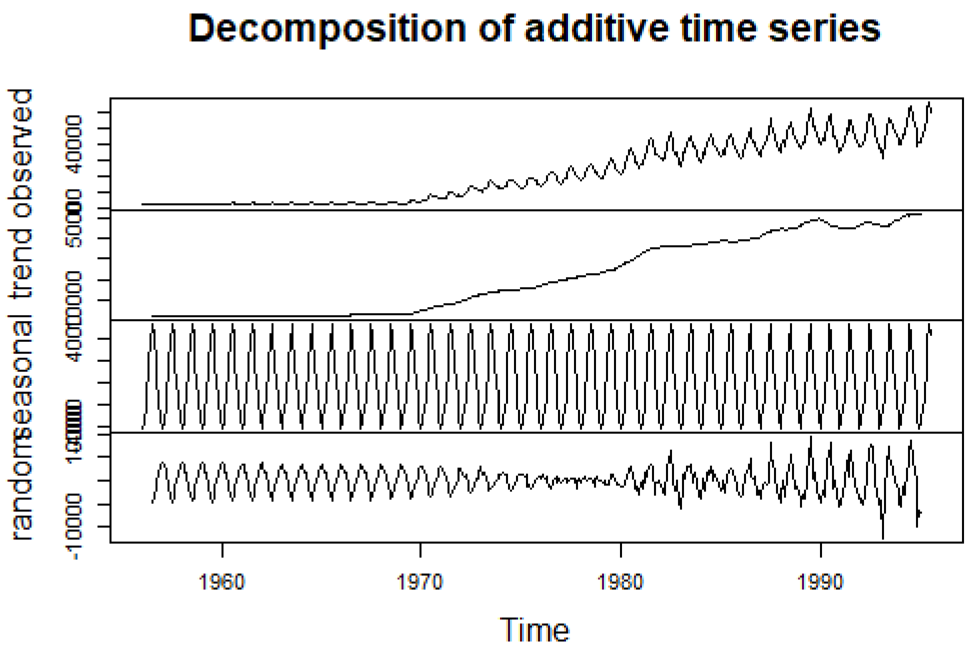


Additive and Multiplicative Model

```
decompgas=decompose(AU.gas, type = "multiplicative")
plot(decompgas)
```




```
decompgas=decompose(AU.gas, type = "additive")
plot(decompgas)
```



Doing a additive decomposition of AU gas production dataset we observe

1. There is trend component taking upward route around 1970s
2. There is strong seasonal component
3. There is random component which shows constant variance till somewhere mid 1970s

This is monthly time series with frequency of 12 observations per year

Decompgas

$x

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1956	1709	1646	1794	1878	2173	2321	2468	2416	2184	2121	1962	1825
1957	1751	1688	1920	1941	2311	2279	2638	2448	2279	2163	1941	1878
1958	1773	1688	1783	1984	2290	2511	2712	2522	2342	2195	1931	1910
1959	1730	1688	1899	1994	2342	2553	2712	2627	2363	2311	2026	1910
1960	1762	1815	2005	2089	2617	2828	2965	2891	2532	2363	2216	2026
1961	1804	1773	2015	2089	2627	2712	3007	2880	2490	2237	2205	1984
1962	1868	1815	2047	2142	2743	2775	3028	2965	2501	2501	2131	2015
1963	1910	1868	2121	2268	2690	2933	3218	3028	2659	2406	2258	2057
1964	1889	1984	2110	2311	2785	3039	3229	3070	2659	2543	2237	2142
1965	1962	1910	2216	2437	2817	3123	3345	3112	2659	2469	2332	2110
1966	1910	1941	2216	2342	2923	3229	3513	3355	2849	2680	2395	2205
1967	1994	1952	2290	2395	2965	3239	3608	3524	3018	2648	2363	2247
1968	1994	1941	2258	2332	3323	3608	3957	3672	3155	2933	2585	2384
1969	2057	2100	2458	2638	3292	3724	4652	4379	4231	3756	3429	3461

1970	3345	4220	4874	5064	5951	6774	7997	7523	7438	6879	6489	6288
1971	5919	6183	6594	6489	8040	9715	9714	9756	8595	7861	7753	8154
1972	7778	7402	8903	9742	11372	12741	13733	13691	12239	12502	11241	10829
1973	11569	10397	12493	11962	13974	14945	16805	16587	14225	14157	13016	12253
1974	11704	12275	13695	14082	16555	17339	17777	17592	16194	15336	14208	13116
1975	12354	12682	14141	14989	16159	18276	19157	18737	17109	17094	15418	14312
1976	13260	14990	15975	16770	19819	20983	22001	22337	20750	19969	17293	16498
1977	15117	16058	18137	18471	21398	23854	26025	25479	22804	19619	19627	18488
1978	17243	18284	20226	20903	23768	26323	28038	26776	22886	22813	22404	19795
1979	18839	18892	20823	22212	25076	26884	30611	30228	26762	25885	23328	21930
1980	21433	22369	24503	25905	30605	34984	37060	34502	31793	29275	28305	25248
1981	27730	27424	32684	31366	37459	41060	43558	42398	33827	34962	33480	32445
1982	30715	30400	31451	31306	40592	44133	47387	41310	37913	34355	34607	28729
1983	26138	30745	35018	34549	40980	42869	45022	40387	38180	38608	35308	30234
1984	28801	33034	35294	33181	40797	42355	46098	42430	41851	39331	37328	34514
1985	32494	33308	36805	34221	41020	44350	46173	44435	40943	39269	35901	32142
1986	31239	32261	34951	38109	43168	45547	49568	45387	41805	41281	36068	34879
1987	32791	34206	39128	40249	43519	46137	56709	52306	49397	45500	39857	37958
1988	35567	37696	42319	39137	47062	50610	54457	54435	48516	43225	42155	39995
1989	37541	37277	41778	41666	49616	57793	61884	62400	50820	51116	45731	42528

1990 40459 40295 44147 42697 52561 56572 56858 58363 45627
45622 41304 36016
1991 35592 35677 39864 41761 50380 49129 55066 55671 49058
44503 42145 38698
1992 38963 38690 39792 42545 50145 58164 59035 59408 55988
47321 42269 39606
1993 37059 37963 31043 41712 50366 56977 56807 54634 51367
48073 46251 43736
1994 39975 40478 46895 46147 55011 57799 62450 63896 57784
53231 50354 38410
1995 41600 41471 46287 49013 56624 61739 66600 60054

$seasonal

Jan Feb Mar Apr May Jun Jul
Aug Sep
1956 -4100.9584 -3738.4649 -2068.0018 -1781.6926 1712.3885
3559.9489 5134.7029 4242.2285 1542.7862
1957 -4100.9584 -3738.4649 -2068.0018 -1781.6926 1712.3885
3559.9489 5134.7029 4242.2285 1542.7862
1958 -4100.9584 -3738.4649 -2068.0018 -1781.6926 1712.3885
3559.9489 5134.7029 4242.2285 1542.7862
1959 -4100.9584 -3738.4649 -2068.0018 -1781.6926 1712.3885
3559.9489 5134.7029 4242.2285 1542.7862
1960 -4100.9584 -3738.4649 -2068.0018 -1781.6926 1712.3885
3559.9489 5134.7029 4242.2285 1542.7862
1961 -4100.9584 -3738.4649 -2068.0018 -1781.6926 1712.3885
3559.9489 5134.7029 4242.2285 1542.7862
1962 -4100.9584 -3738.4649 -2068.0018 -1781.6926 1712.3885
3559.9489 5134.7029 4242.2285 1542.7862
1963 -4100.9584 -3738.4649 -2068.0018 -1781.6926 1712.3885
3559.9489 5134.7029 4242.2285 1542.7862
1964 -4100.9584 -3738.4649 -2068.0018 -1781.6926 1712.3885
3559.9489 5134.7029 4242.2285 1542.7862
1965 -4100.9584 -3738.4649 -2068.0018 -1781.6926 1712.3885
3559.9489 5134.7029 4242.2285 1542.7862
1966 -4100.9584 -3738.4649 -2068.0018 -1781.6926 1712.3885
3559.9489 5134.7029 4242.2285 1542.7862
1967 -4100.9584 -3738.4649 -2068.0018 -1781.6926 1712.3885
3559.9489 5134.7029 4242.2285 1542.7862

1968 -4100.9584 -3738.4649 -2068.0018 -1781.6926 1712.3885
3559.9489 5134.7029 4242.2285 1542.7862
1969 -4100.9584 -3738.4649 -2068.0018 -1781.6926 1712.3885
3559.9489 5134.7029 4242.2285 1542.7862
1970 -4100.9584 -3738.4649 -2068.0018 -1781.6926 1712.3885
3559.9489 5134.7029 4242.2285 1542.7862
1971 -4100.9584 -3738.4649 -2068.0018 -1781.6926 1712.3885
3559.9489 5134.7029 4242.2285 1542.7862
1972 -4100.9584 -3738.4649 -2068.0018 -1781.6926 1712.3885
3559.9489 5134.7029 4242.2285 1542.7862
1973 -4100.9584 -3738.4649 -2068.0018 -1781.6926 1712.3885
3559.9489 5134.7029 4242.2285 1542.7862
1974 -4100.9584 -3738.4649 -2068.0018 -1781.6926 1712.3885
3559.9489 5134.7029 4242.2285 1542.7862
1975 -4100.9584 -3738.4649 -2068.0018 -1781.6926 1712.3885
3559.9489 5134.7029 4242.2285 1542.7862
1976 -4100.9584 -3738.4649 -2068.0018 -1781.6926 1712.3885
3559.9489 5134.7029 4242.2285 1542.7862
1977 -4100.9584 -3738.4649 -2068.0018 -1781.6926 1712.3885
3559.9489 5134.7029 4242.2285 1542.7862
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3559.9489 5134.7029 4242.2285 1542.7862
1979 -4100.9584 -3738.4649 -2068.0018 -1781.6926 1712.3885
3559.9489 5134.7029 4242.2285 1542.7862
1980 -4100.9584 -3738.4649 -2068.0018 -1781.6926 1712.3885
3559.9489 5134.7029 4242.2285 1542.7862
1981 -4100.9584 -3738.4649 -2068.0018 -1781.6926 1712.3885
3559.9489 5134.7029 4242.2285 1542.7862
1982 -4100.9584 -3738.4649 -2068.0018 -1781.6926 1712.3885
3559.9489 5134.7029 4242.2285 1542.7862
1983 -4100.9584 -3738.4649 -2068.0018 -1781.6926 1712.3885
3559.9489 5134.7029 4242.2285 1542.7862
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1994	196.7136	-1431.3570	-3268.2939
1995			

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	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct
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1957	2079.250	2087.667	2092.958	2098.667	2099.542	2100.875	2104.000	2104.917	2099.208	2095.292
1958	2117.750	2123.917	2129.625	2133.583	2134.500	2135.417	2134.958	2133.167	2138.000	2143.250
1959	2151.500	2155.875	2161.125	2166.833	2175.625	2179.583	2180.917	2187.542	2197.250	2205.625
1960	2265.958	2287.500	2305.542	2314.750	2324.833	2337.583	2344.167	2344.167	2342.833	2343.250
1961	2336.167	2337.458	2335.250	2328.250	2322.542	2320.333	2321.250	2325.667	2328.750	2332.292
1962	2350.292	2354.708	2358.708	2370.167	2378.083	2376.292	2379.333	2383.292	2388.583	2396.917
1963	2418.833	2429.375	2438.583	2441.208	2442.542	2449.583	2450.458	2454.417	2458.792	2460.125
1964	2479.125	2481.333	2483.083	2488.792	2493.625	2496.292	2502.875	2502.833	2504.167	2513.833

1965	2533.583	2540.167	2541.917	2538.833	2539.708	2542.333	2538.833	2537.958	2539.250	2535.292		
1966	2556.000	2573.125	2591.167	2607.875	2619.292	2625.875	2633.333	2637.292	2640.833	2646.125		
1967	2656.625	2667.625	2681.708	2687.417	2684.750	2685.167	2686.917	2686.458	2684.667	2680.708		
1968	2753.208	2773.917	2785.792	2803.375	2824.500	2839.458	2847.792	2857.042	2872.000	2893.083		
1969	2941.875	3000.292	3074.583	3153.708	3223.167	3303.208	3401.750	3543.750	3732.750	3934.500		
1970	4650.708	4921.083	5185.708	5449.458	5707.083	5952.375	6177.417	6366.458	6519.917	6650.958		
1971	7201.042	7365.625	7506.875	7596.000	7689.583	7820.000	7975.208	8103.458	8250.458	8482.208		
1972	9315.042	9646.458	9962.250	10307.458	10646.167	10902.958	11172.375	11455.125	11729.500	11971.583		
1973	12592.583	12841.250	13044.667	13196.375	13339.292	13472.583	13537.542	13621.417	13749.750	13888.167		
1974	14431.583	14513.958	14637.875	14769.042	14867.833	14953.458	15016.500	15060.542	15096.083	15152.458		
1975	15292.833	15398.042	15483.875	15595.250	15718.917	15819.167	15906.750	16040.667	16213.250	16363.875		
1976	17087.167	17355.667	17657.375	17928.875	18126.792	18296.000	18464.458	18586.333	18720.917	18881.875		
1977	19491.250	19789.833	20006.333	20077.333	20160.000	20340.167	20511.667	20693.000	20872.792	21061.167		
1978	21649.625	21787.542	21845.000	21981.500	22230.292	22400.458	22521.417	22613.250	22663.458	22742.875		
1979	23060.375	23311.417	23616.750	23906.250	24072.750	24200.208	24397.250	24650.208	24948.417	25255.625		
1980	26813.958	27260.750	27648.458	27999.333	28347.958	28693.583	29094.208	29567.208	30118.708	30687.125		
1981	32262.917	32862.667	33276.417	33598.125	34050.708	34566.208	34990.458	35238.833	35311.458	35257.583		
1982	35931.792	36046.000	36170.917	36315.875	36337.542	36229.667	35884.125	35707.792	35870.792	36154.542		
1983	36118.125	35981.125	35953.792	36142.125	36348.542	36440.458	36614.125	36820.458	36927.333	36881.833		
1984	36811.583	36941.542	37179.625	37362.708	37477.000	37739.500	38071.708	38237.000	38311.375	38417.667		

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1958	2145.833	2149.750
1959	2221.042	2243.958
1960	2343.667	2339.250
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1962	2399.958	2404.333
1963	2465.875	2474.250
1964	2520.417	2525.250
1965	2535.750	2544.583
1966	2650.083	2652.250
1967	2693.000	2723.292
1968	2904.542	2908.083
1969	4146.375	4384.250
1970	6797.375	7006.958
1971	8756.583	9021.500
1972	12172.500	12372.750

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Jul
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1959   3679.458448   3270.589858   1805.876802   1608.859258   -
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1993	-4100.9584	-3738.4649	-2068.0018	-1781.6926	1712.3885	3559.9489	5134.7029	4242.2285	1542.7862
1994	-4100.9584	-3738.4649	-2068.0018	-1781.6926	1712.3885	3559.9489	5134.7029	4242.2285	1542.7862
1995	-4100.9584	-3738.4649	-2068.0018	-1781.6926	1712.3885	3559.9489	5134.7029	4242.2285	

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1957	196.7136	-1431.3570	-3268.2939
1958	196.7136	-1431.3570	-3268.2939
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1988	196.7136	-1431.3570	-3268.2939

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1994   196.7136 -1431.3570 -3268.2939
1995
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decompgas$trend

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1958  2117.750  2123.917  2129.625  2133.583  2134.500  2135.417
2134.958  2133.167  2138.000  2143.250
1959  2151.500  2155.875  2161.125  2166.833  2175.625  2179.583
2180.917  2187.542  2197.250  2205.625
1960  2265.958  2287.500  2305.542  2314.750  2324.833  2337.583
2344.167  2344.167  2342.833  2343.250
1961  2336.167  2337.458  2335.250  2328.250  2322.542  2320.333
2321.250  2325.667  2328.750  2332.292
1962  2350.292  2354.708  2358.708  2370.167  2378.083  2376.292
2379.333  2383.292  2388.583  2396.917
1963  2418.833  2429.375  2438.583  2441.208  2442.542  2449.583
2450.458  2454.417  2458.792  2460.125
1964  2479.125  2481.333  2483.083  2488.792  2493.625  2496.292
2502.875  2502.833  2504.167  2513.833
1965  2533.583  2540.167  2541.917  2538.833  2539.708  2542.333
2538.833  2537.958  2539.250  2535.292
1966  2556.000  2573.125  2591.167  2607.875  2619.292  2625.875
2633.333  2637.292  2640.833  2646.125
1967  2656.625  2667.625  2681.708  2687.417  2684.750  2685.167
2686.917  2686.458  2684.667  2680.708
1968  2753.208  2773.917  2785.792  2803.375  2824.500  2839.458
2847.792  2857.042  2872.000  2893.083
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1972 9315.042 9646.458 9962.250 10307.458 10646.167 10902.958
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1973 12592.583 12841.250 13044.667 13196.375 13339.292 13472.583
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1974 14431.583 14513.958 14637.875 14769.042 14867.833 14953.458
15016.500 15060.542 15096.083 15152.458
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1989 46013.958 46655.292 47083.167 47507.958 47985.750 48240.292
48467.417 48714.750 48939.208 49080.875

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1993	46469.417	46177.667	45786.208	45625.000	45822.250	46160.250	46453.833	46680.125	47445.417	48290.708
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1962	2399.958	2404.333
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1964	2520.417	2525.250
1965	2535.750	2544.583
1966	2650.083	2652.250
1967	2693.000	2723.292
1968	2904.542	2908.083
1969	4146.375	4384.250
1970	6797.375	7006.958
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1973	14084.042	14291.333
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1982	36305.833	36269.333

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decompgas$random

Jan Feb Mar Apr May Jun Jul
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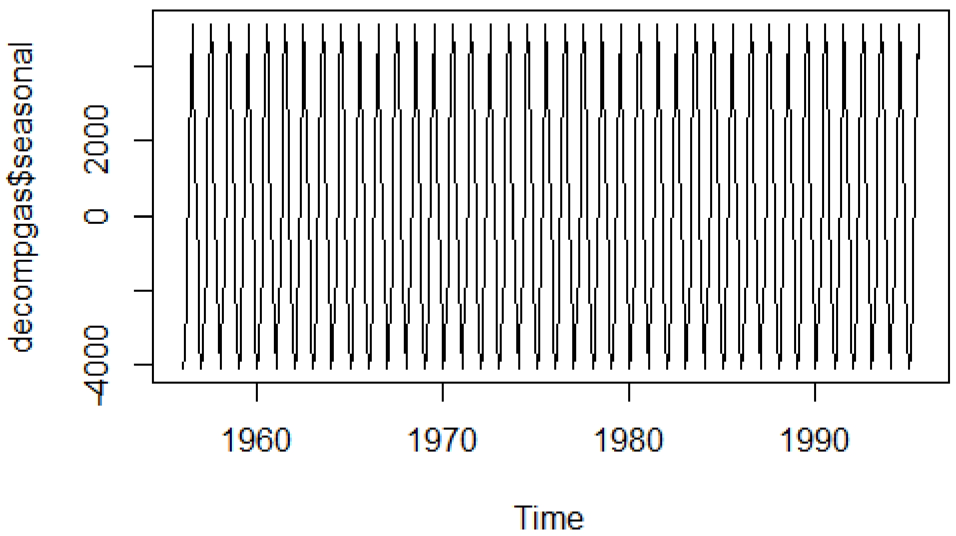
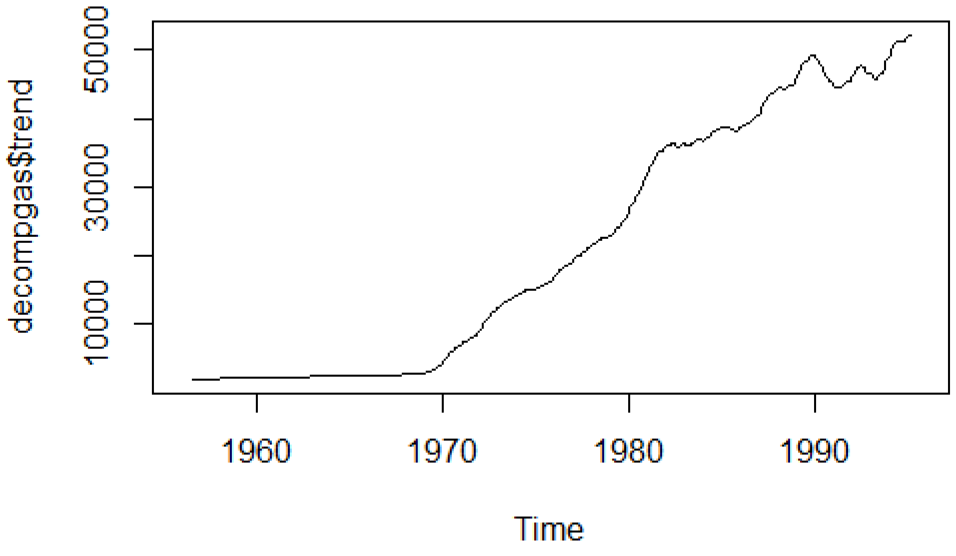
1991   6226.979816   2190.880457  -1047.713560  -1800.518048  -3777.247748
1992   7694.229816   7368.505457    446.828106  -2951.601381  -3737.414415
1993   3711.646482   2378.797123   -414.421894   -986.684714  -1892.539415
1994   8441.146482   5012.547123   1711.536440    275.981952 -10062.456082
1995            NA
```

Plotting Individual

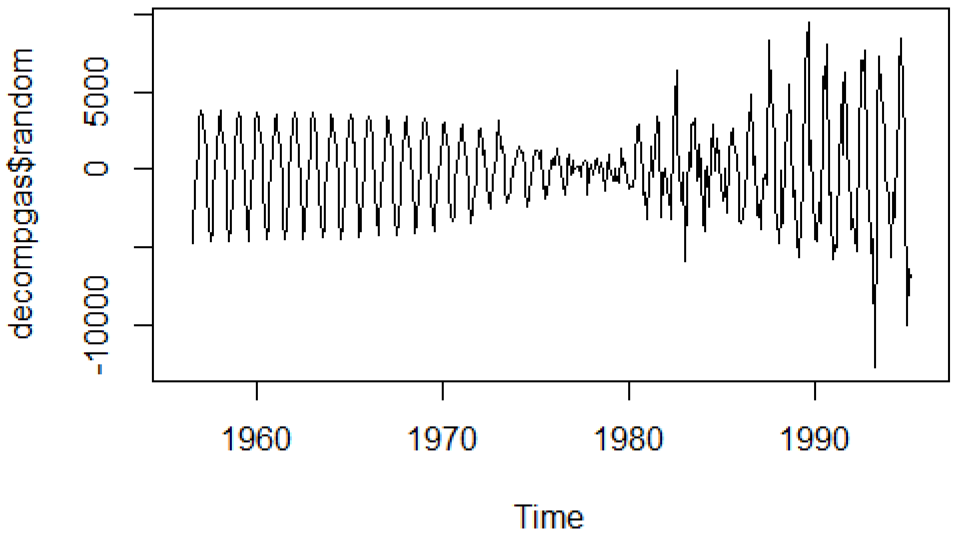
plot(decompgas$seasonal)



plot(decompgas$trend)



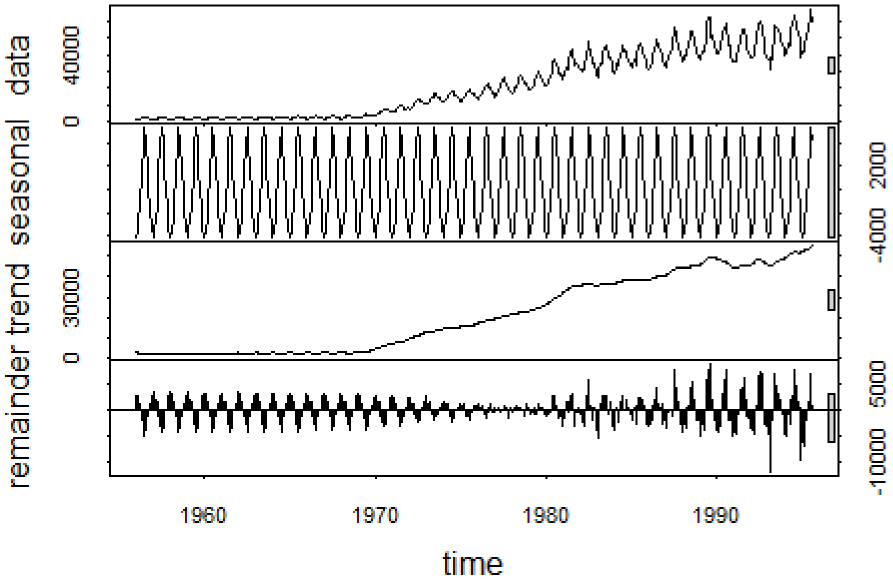
plot(decompgas$random)



output=(decompgas$trend+decompgas$random)
output_trend<-

Using ST1l Function

plot(stl(AU.gas, s.window = "periodic"))



AU.gas.ts2=stl(AU.gas, s.window = "periodic")
AU.gas.ts2

```
Call:
 stl(x = AU.gas, s.window = "periodic")
Components
          seasonal    trend    remainder
Jan 1956 -4083.7994  3000.295   2792.50473
Feb 1956 -3715.9678  2792.712   2569.25583
Mar 1956 -2165.1863  2585.129   1374.05703
Apr 1956 -1809.3076  2461.267   1226.04094
May 1956  1713.8461  2337.404  -1878.25008
Jun 1956  3591.8664  2261.258  -3532.12392
Jul 1956  5312.5120  2185.111  -5029.62308
```

Aug 1956	4256.0658	2100.722	-3940.78794
Sep 1956	1528.2903	2016.333	-1360.62357
Oct 1956	163.9636	2115.969	-158.93237
Nov 1956	-1471.7225	2215.604	1218.11825
Dec 1956	-3320.5600	2333.018	2812.54224
Jan 1957	-4083.7994	2450.431	3384.36823
Feb 1957	-3715.9678	2379.171	3024.79674
Mar 1957	-2165.1863	2307.911	1777.27535
Apr 1957	-1809.3076	2127.690	1622.61780
May 1957	1713.8461	1947.469	-1350.31467
Jun 1957	3591.8664	1848.064	-3160.93037
Jul 1957	5312.5120	1748.659	-4423.17138
Aug 1957	4256.0658	1813.580	-3621.64562
Sep 1957	1528.2903	1878.500	-1127.79062
Oct 1957	163.9636	2062.935	-63.89864
Nov 1957	-1471.7225	2247.370	1165.35277
Dec 1957	-3320.5600	2363.266	2835.29385
Jan 1958	-4083.7994	2479.162	3377.63692
Feb 1958	-3715.9678	2409.680	2994.28730
Mar 1958	-2165.1863	2340.199	1607.98779
Apr 1958	-1809.3076	2161.713	1631.59472
May 1958	1713.8461	1983.227	-1407.07326
Jun 1958	3591.8664	1884.956	-2965.82191
Jul 1958	5312.5120	1786.684	-4387.19588
Aug 1958	4256.0658	1853.630	-3587.69588
Sep 1958	1528.2903	1920.576	-1106.86664
Oct 1958	163.9636	2105.137	-74.10048
Nov 1958	-1471.7225	2289.697	1113.02509
Dec 1958	-3320.5600	2401.617	2828.94271
Jan 1959	-4083.7994	2513.537	3300.26232
Feb 1959	-3715.9678	2442.855	2961.11275
Mar 1959	-2165.1863	2372.173	1692.01329
Apr 1959	-1809.3076	2197.581	1605.72609
May 1959	1713.8461	2022.990	-1394.83603
Jun 1959	3591.8664	1929.417	-2968.28349

Jul 1959	5312.5120	1835.844	-4436.35628
Aug 1959	4256.0658	1907.484	-3536.55008
Sep 1959	1528.2903	1979.124	-1144.41464
Oct 1959	163.9636	2172.498	-25.46135
Nov 1959	-1471.7225	2365.871	1131.85135
Dec 1959	-3320.5600	2493.549	2737.01053
Jan 1960	-4083.7994	2621.228	3224.57169
Feb 1960	-3715.9678	2566.047	2964.92075
Mar 1960	-2165.1863	2510.866	1659.31991
Apr 1960	-1809.3076	2346.502	1551.80530
May 1960	1713.8461	2182.138	-1278.98423
Jun 1960	3591.8664	2092.325	-2856.19105
Jul 1960	5312.5120	2002.511	-4350.02321
Aug 1960	4256.0658	2067.275	-3432.34066
Sep 1960	1528.2903	2132.039	-1128.32889
Oct 1960	163.9636	2307.325	-108.28820
Nov 1960	-1471.7225	2482.611	1205.11192
Dec 1960	-3320.5600	2586.668	2759.89208
Jan 1961	-4083.7994	2690.725	3197.07424
Feb 1961	-3715.9678	2614.672	2874.29621
Mar 1961	-2165.1863	2538.618	1641.56828
Apr 1961	-1809.3076	2358.543	1539.76457
May 1961	1713.8461	2178.468	-1265.31406
Jun 1961	3591.8664	2080.397	-2960.26290
Jul 1961	5312.5120	1982.325	-4287.83706
Aug 1961	4256.0658	2048.106	-3424.17215
Sep 1961	1528.2903	2113.888	-1152.17801
Oct 1961	163.9636	2295.612	-222.57579
Nov 1961	-1471.7225	2477.337	1199.38586
Dec 1961	-3320.5600	2589.926	2714.63439
Jan 1962	-4083.7994	2702.514	3249.28492
Feb 1962	-3715.9678	2636.394	2894.57393
Mar 1962	-2165.1863	2570.273	1641.91305
Apr 1962	-1809.3076	2400.088	1551.22004
May 1962	1713.8461	2229.902	-1200.74790

Jun 1962	3591.8664	2136.080	-2952.94641
Jul 1962	5312.5120	2042.258	-4326.77024
Aug 1962	4256.0658	2108.492	-3399.55781
Sep 1962	1528.2903	2174.726	-1202.01615
Oct 1962	163.9636	2356.422	-19.38563
Nov 1962	-1471.7225	2538.118	1064.60431
Dec 1962	-3320.5600	2652.947	2682.61253
Jan 1963	-4083.7994	2767.777	3226.02273
Feb 1963	-3715.9678	2704.827	2879.14104
Mar 1963	-2165.1863	2641.877	1644.30946
Apr 1963	-1809.3076	2472.753	1604.55426
May 1963	1713.8461	2303.630	-1327.47586
Jun 1963	3591.8664	2210.048	-2868.91412
Jul 1963	5312.5120	2116.466	-4210.97770
Aug 1963	4256.0658	2180.771	-3408.83673
Sep 1963	1528.2903	2245.076	-1114.36653
Oct 1963	163.9636	2423.672	-181.63569
Nov 1963	-1471.7225	2602.268	1127.45457
Dec 1963	-3320.5600	2713.282	2664.27789
Jan 1964	-4083.7994	2824.296	3148.50319
Feb 1964	-3715.9678	2757.807	2942.16130
Mar 1964	-2165.1863	2691.317	1583.86952
Apr 1964	-1809.3076	2522.048	1598.25932
May 1964	1713.8461	2352.780	-1281.62581
Jun 1964	3591.8664	2259.615	-2812.48114
Jul 1964	5312.5120	2166.450	-4249.96180
Aug 1964	4256.0658	2230.649	-3416.71428
Sep 1964	1528.2903	2294.847	-1164.13753
Oct 1964	163.9636	2473.943	-94.90705
Nov 1964	-1471.7225	2653.040	1055.68285
Dec 1964	-3320.5600	2765.827	2696.73262
Jan 1965	-4083.7994	2878.615	3167.18439
Feb 1965	-3715.9678	2812.918	2813.04934
Mar 1965	-2165.1863	2747.222	1633.96440
Apr 1965	-1809.3076	2575.398	1670.91003

May 1965	1713.8461	2403.573	-1300.41927
Jun 1965	3591.8664	2305.902	-2774.76841
Jul 1965	5312.5120	2208.231	-4175.74287
Aug 1965	4256.0658	2266.392	-3410.45765
Sep 1965	1528.2903	2324.553	-1193.84321
Oct 1965	163.9636	2497.239	-192.20300
Nov 1965	-1471.7225	2669.926	1133.79663
Dec 1965	-3320.5600	2784.160	2646.39953
Jan 1966	-4083.7994	2898.395	3095.40442
Feb 1966	-3715.9678	2844.836	2812.13169
Mar 1966	-2165.1863	2791.277	1589.90907
Apr 1966	-1809.3076	2635.405	1515.90260
May 1966	1713.8461	2479.533	-1270.37880
Jun 1966	3591.8664	2393.690	-2756.55631
Jul 1966	5312.5120	2307.847	-4107.35916
Aug 1966	4256.0658	2372.828	-3273.89359
Sep 1966	1528.2903	2437.808	-1117.09879
Oct 1966	163.9636	2610.288	-94.25136
Nov 1966	-1471.7225	2782.767	1083.95548
Dec 1966	-3320.5600	2889.433	2636.12697
Jan 1967	-4083.7994	2996.099	3081.70044
Feb 1967	-3715.9678	2934.470	2733.49800
Mar 1967	-2165.1863	2872.841	1582.34568
Apr 1967	-1809.3076	2710.283	1494.02439
May 1967	1713.8461	2547.726	-1296.57182
Jun 1967	3591.8664	2456.627	-2809.49296
Jul 1967	5312.5120	2365.527	-4070.03943
Aug 1967	4256.0658	2425.056	-3157.12165
Sep 1967	1528.2903	2484.584	-994.87464
Oct 1967	163.9636	2658.324	-174.28742
Nov 1967	-1471.7225	2832.063	1002.65921
Dec 1967	-3320.5600	2951.194	2616.36596
Jan 1968	-4083.7994	3070.325	3007.47471
Feb 1968	-3715.9678	3024.231	2632.73696
Mar 1968	-2165.1863	2978.137	1445.04932

Apr 1968	-1809.3076	2833.487	1307.82061
May 1968	1713.8461	2688.837	-1079.68303
Jun 1968	3591.8664	2614.227	-2598.09293
Jul 1968	5312.5120	2539.616	-3895.12815
Aug 1968	4256.0658	2610.429	-3194.49465
Sep 1968	1528.2903	2681.242	-1054.53190
Oct 1968	163.9636	2855.062	-86.02572
Nov 1968	-1471.7225	3028.883	1027.83988
Dec 1968	-3320.5600	3149.738	2554.82243
Jan 1969	-4083.7994	3270.592	2870.20697
Feb 1969	-3715.9678	3257.759	2558.20905
Mar 1969	-2165.1863	3244.925	1378.26123
Apr 1969	-1809.3076	3161.328	1285.97978
May 1969	1713.8461	3077.730	-1499.57658
Jun 1969	3591.8664	3092.145	-2960.01109
Jul 1969	5312.5120	3106.559	-3767.07092
Aug 1969	4256.0658	3319.015	-3196.08120
Sep 1969	1528.2903	3531.472	-828.76225
Oct 1969	163.9636	3897.679	-305.64244
Nov 1969	-1471.7225	4263.886	636.83678
Dec 1969	-3320.5600	4606.160	2175.40004
Jan 1970	-4083.7994	4948.434	2480.36529
Feb 1970	-3715.9678	5154.938	2781.02977
Mar 1970	-2165.1863	5361.442	1677.74436
Apr 1970	-1809.3076	5476.726	1396.58126
May 1970	1713.8461	5592.011	-1354.85675
Jun 1970	3591.8664	5740.503	-2558.36940
Jul 1970	5312.5120	5888.995	-3204.50737
Aug 1970	4256.0658	6122.533	-2855.59859
Sep 1970	1528.2903	6356.070	-446.36056
Oct 1970	163.9636	6658.479	56.55689
Nov 1970	-1471.7225	6960.889	999.83377
Dec 1970	-3320.5600	7210.547	2398.01322
Jan 1971	-4083.7994	7460.205	2542.59466
Feb 1971	-3715.9678	7547.807	2351.16105

Mar 1971	-2165.1863	7635.409	1123.77754
Apr 1971	-1809.3076	7616.536	681.77198
May 1971	1713.8461	7597.662	-1271.50850
Jun 1971	3591.8664	7650.173	-1527.03972
Jul 1971	5312.5120	7702.684	-3301.19627
Aug 1971	4256.0658	7911.286	-2411.35182
Sep 1971	1528.2903	8119.888	-1053.17813
Oct 1971	163.9636	8470.825	-773.78889
Nov 1971	-1471.7225	8821.763	402.95977
Dec 1971	-3320.5600	9184.641	2289.91914
Jan 1972	-4083.7994	9547.519	2314.28050
Feb 1972	-3715.9678	9829.624	1288.34395
Mar 1972	-2165.1863	10111.729	956.45750
Apr 1972	-1809.3076	10319.764	1231.54402
May 1972	1713.8461	10527.798	-869.64439
Jun 1972	3591.8664	10756.307	-1607.17346
Jul 1972	5312.5120	10984.816	-2564.32786
Aug 1972	4256.0658	11289.412	-1854.47747
Sep 1972	1528.2903	11594.008	-883.29785
Oct 1972	163.9636	11933.039	404.99712
Nov 1972	-1471.7225	12272.071	440.65151
Dec 1972	-3320.5600	12548.563	1600.99669
Jan 1973	-4083.7994	12825.056	2827.74386
Feb 1973	-3715.9678	12982.385	1130.58315
Mar 1973	-2165.1863	13139.714	1518.47255
Apr 1973	-1809.3076	13196.967	574.34059
May 1973	1713.8461	13254.220	-994.06629
Jun 1973	3591.8664	13310.288	-1957.15390
Jul 1973	5312.5120	13366.355	-1873.86684
Aug 1973	4256.0658	13510.094	-1179.16024
Sep 1973	1528.2903	13653.834	-957.12442
Oct 1973	163.9636	13897.737	95.29894
Nov 1973	-1471.7225	14141.641	346.08171
Dec 1973	-3320.5600	14354.989	1218.57085
Jan 1974	-4083.7994	14568.337	1219.46199

Feb	1974	-3715.9678	14666.046	1324.92131
Mar	1974	-2165.1863	14763.756	1096.43074
Apr	1974	-1809.3076	14791.952	1099.35605
May	1974	1713.8461	14820.147	21.00644
Jun	1974	3591.8664	14846.258	-1099.12402
Jul	1974	5312.5120	14872.368	-2407.87981
Aug	1974	4256.0658	14936.015	-1600.08061
Sep	1974	1528.2903	14999.662	-333.95218
Oct	1974	163.9636	15111.099	60.93689
Nov	1974	-1471.7225	15222.537	457.18538
Dec	1974	-3320.5600	15332.213	1104.34727
Jan	1975	-4083.7994	15441.888	995.91115
Feb	1975	-3715.9678	15503.908	894.05945
Mar	1975	-2165.1863	15565.928	740.25786
Apr	1975	-1809.3076	15602.883	1195.42478
May	1975	1713.8461	15639.837	-1194.68322
Jun	1975	3591.8664	15716.829	-1032.69579
Jul	1975	5312.5120	15793.822	-1949.33369
Aug	1975	4256.0658	15956.766	-1475.83136
Sep	1975	1528.2903	16119.709	-538.99980
Oct	1975	163.9636	16378.921	551.11580
Nov	1975	-1471.7225	16638.132	251.59082
Dec	1975	-3320.5600	16923.141	709.41864
Jan	1976	-4083.7994	17208.151	135.64844
Feb	1976	-3715.9678	17453.005	1252.96329
Mar	1976	-2165.1863	17697.858	442.32825
Apr	1976	-1809.3076	17889.769	689.53869
May	1976	1713.8461	18081.680	23.47420
Jun	1976	3591.8664	18239.031	-847.89703
Jul	1976	5312.5120	18396.382	-1707.89358
Aug	1976	4256.0658	18548.770	-467.83532
Sep	1976	1528.2903	18701.157	520.55218
Oct	1976	163.9636	18888.111	916.92489
Nov	1976	-1471.7225	19075.066	-310.34299
Dec	1976	-3320.5600	19300.746	517.81386

Jan	1977	-4083.7994	19526.427	-325.62730
Feb	1977	-3715.9678	19728.963	45.00472
Mar	1977	-2165.1863	19931.499	370.68684
Apr	1977	-1809.3076	20073.825	206.48291
May	1977	1713.8461	20216.150	-531.99595
Jun	1977	3591.8664	20364.032	-101.89881
Jul	1977	5312.5120	20511.915	200.57300
Aug	1977	4256.0658	20685.981	536.95350
Sep	1977	1528.2903	20860.046	415.66323
Oct	1977	163.9636	21050.922	-1595.88577
Nov	1977	-1471.7225	21241.798	-143.07535
Dec	1977	-3320.5600	21429.666	378.89435
Jan	1978	-4083.7994	21617.533	-290.73396
Feb	1978	-3715.9678	21771.256	228.71169
Mar	1978	-2165.1863	21924.979	466.20745
Apr	1978	-1809.3076	22079.176	633.13132
May	1978	1713.8461	22233.374	-179.21973
Jun	1978	3591.8664	22362.700	368.43394
Jul	1978	5312.5120	22492.026	233.46228
Aug	1978	4256.0658	22581.055	-61.12029
Sep	1978	1528.2903	22670.083	-1312.37362
Oct	1978	163.9636	22751.098	-102.06162
Nov	1978	-1471.7225	22832.113	1043.60981
Dec	1978	-3320.5600	22970.967	144.59309
Jan	1979	-4083.7994	23109.821	-187.02164
Feb	1979	-3715.9678	23330.179	-722.21139
Mar	1979	-2165.1863	23550.537	-562.35103
Apr	1979	-1809.3076	23787.702	233.60525
May	1979	1713.8461	24024.867	-662.71339
Jun	1979	3591.8664	24245.116	-952.98284
Jul	1979	5312.5120	24465.366	833.12239
Aug	1979	4256.0658	24727.827	1244.10699
Sep	1979	1528.2903	24990.289	243.42082
Oct	1979	163.9636	25336.443	384.59320
Nov	1979	-1471.7225	25682.598	-882.87500

Dec	1979	-3320.5600	26144.492	-893.93159
Jan	1980	-4083.7994	26606.386	-1089.58619
Feb	1980	-3715.9678	27090.586	-1005.61786
Mar	1980	-2165.1863	27574.786	-906.59943
Apr	1980	-1809.3076	28017.702	-303.39485
May	1980	1713.8461	28460.619	430.53480
Jun	1980	3591.8664	28870.852	2521.28146
Jul	1980	5312.5120	29281.085	2466.40279
Aug	1980	4256.0658	29707.731	538.20333
Sep	1980	1528.2903	30134.377	130.33310
Oct	1980	163.9636	30587.308	-1476.27175
Nov	1980	-1471.7225	31040.240	-1263.51717
Dec	1980	-3320.5600	31572.407	-3003.84705
Jan	1981	-4083.7994	32104.574	-290.77494
Feb	1981	-3715.9678	32678.979	-1539.01124
Mar	1981	-2165.1863	33253.384	1595.80257
Apr	1981	-1809.3076	33779.544	-604.23628
May	1981	1713.8461	34305.704	1439.44995
Jun	1981	3591.8664	34690.229	2777.90449
Jul	1981	5312.5120	35074.754	3170.73371
Aug	1981	4256.0658	35215.498	2926.43603
Sep	1981	1528.2903	35356.242	-3057.53242
Oct	1981	163.9636	35361.111	-563.07503
Nov	1981	-1471.7225	35365.981	-414.25823
Dec	1981	-3320.5600	35499.255	266.30495
Jan	1982	-4083.7994	35632.529	-833.72988
Feb	1982	-3715.9678	35865.288	-1749.32000
Mar	1982	-2165.1863	36098.046	-2481.86000
Apr	1982	-1809.3076	36251.730	-3136.42227
May	1982	1713.8461	36405.413	2472.74053
Jun	1982	3591.8664	36339.626	4201.50771
Jul	1982	5312.5120	36273.838	5800.64956
Aug	1982	4256.0658	36175.581	878.35355
Sep	1982	1528.2903	36077.323	307.38677
Oct	1982	163.9636	36001.310	-1810.27406

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Nov 1982 -1471.7225 35925.298    153.42453
Dec 1982 -3320.5600 35871.964  -3822.40393
Jan 1983 -4083.7994 35818.630  -5596.83041
Feb 1983 -3715.9678 35907.307  -1446.33941
Mar 1983 -2165.1863 35995.985   1187.20170
Apr 1983 -1809.3076 36248.119    110.18807
May 1983  1713.8461 36500.254   2765.89952
Jun 1983  3591.8664 36686.348   2590.78560
Jul 1983  5312.5120 36872.442   2837.04635
Aug 1983  4256.0658 36893.169   -762.23526
Sep 1983  1528.2903 36913.897   -262.18764
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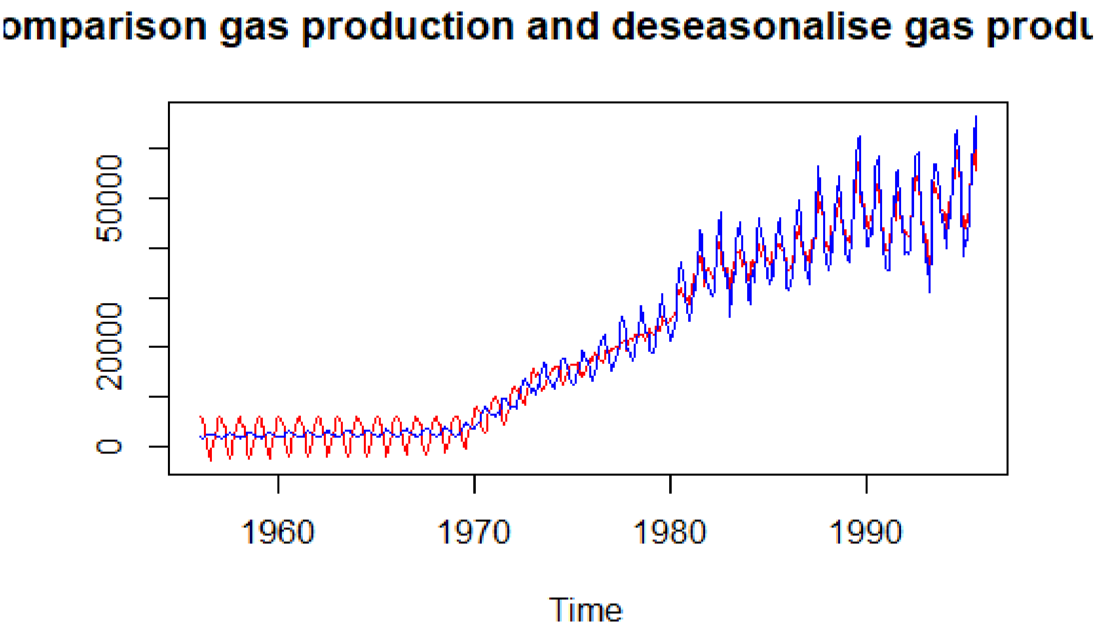
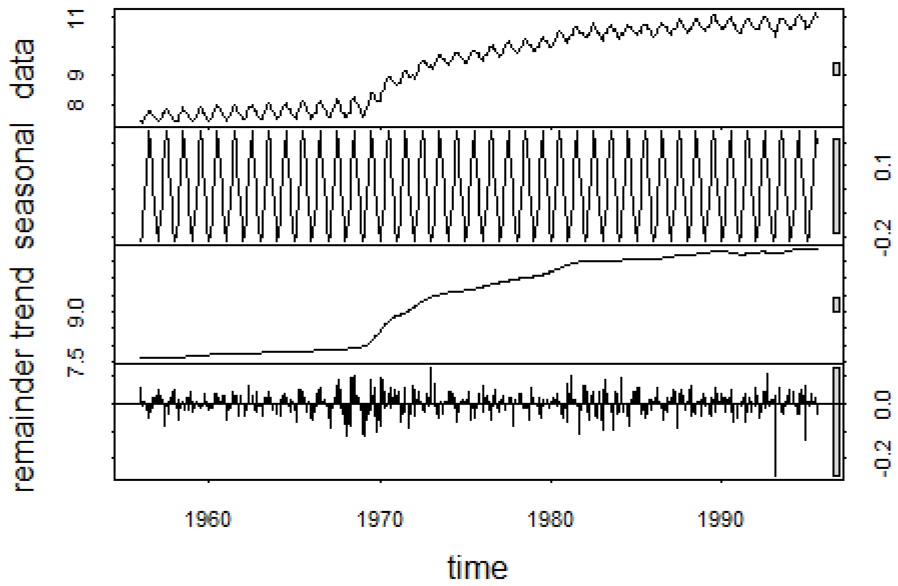
```
deseasongas=(AU.gas.ts2$time.series[,2]+AU.gas.ts2$time.series[,3])
ts.plot(deseasongas,AU.gas,col=c("red","blue"),
main="comparison gas production and deseasonalise gas production")
```



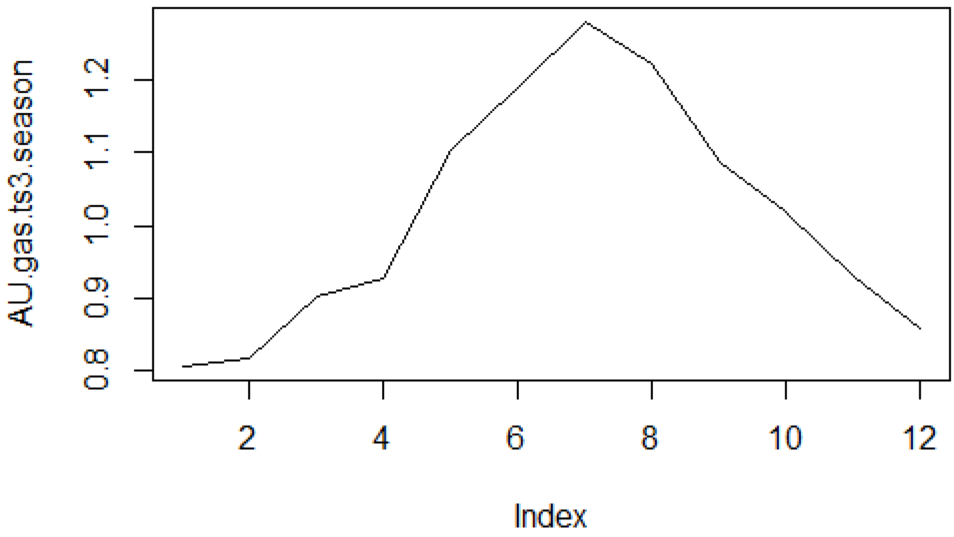
plot(stl(log(AU.gas), s.window = "periodic"))




```
AU.gas.ts3=stl(log(AU.gas), s.window = "periodic")
AU.gas.ts3$time.series[1:12,1]
```

```
[1] -0.21374147 -0.20148305 -0.10369589 -0.07438385
0.09733854  0.17340021  0.24588515  0.20049373
 [9]  0.08234069  0.01736092 -0.07101050 -0.15250449
```

```
AU.gas.ts3.season=exp(AU.gas.ts3$time.series[1:12,1])
plot(AU.gas.ts3.season,type = "l")
```



Stationarity

Visual observation of decomposed plot clearly tells us that since both trend and seasonality are present in this series hence it is ***Not Stationary***

Dicky Fuller test for Stationarity

Hypothesis for ADF test

Null hypothesis Ho : Time series non-stationary

Alternative hypothesis Ha : Time series is stationary

Applying Dicky Fuller Test for Stationarity

```
adf.test(AU.gas)

Augmented Dickey-Fuller Test

data:  AU.gas
Dickey-Fuller = -2.7131, Lag order = 7, p-value = 0.2764
alternative hypothesis: stationary
```

p-value = 0.2764

Since p-value is much greater than significant value of 0.05 we fail to reject the Null Hypothesis Ho

Time series AU.gas is not-stationary **Time series AU.gas is not-stationary**

De-seasonalize the data

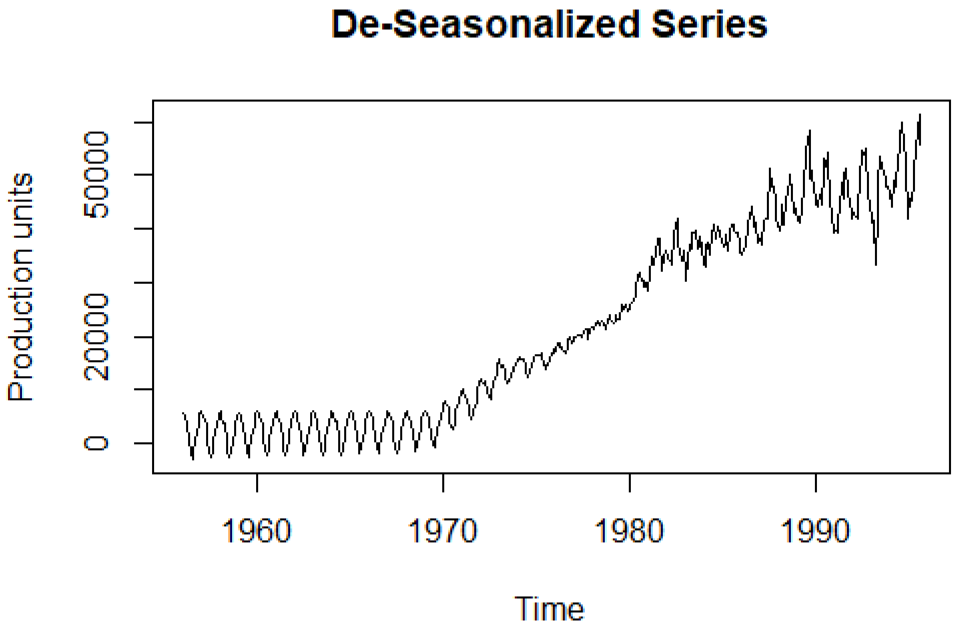
Since AU gas production data series is seasonal data it can be de-sesonalized by taking out the seasonal component of series

Decomposing the AU Series

```
decomposed = stl(AU.gas, s.window = "periodic")
seasonal = decomposed$time.series[,1]
trend = decomposed$time.series[,2]
remainder = decomposed$time.series[,3]
```

Removing the Seasonality

```
des.data = AU.gas – seasonal
plot(des.data, ylab= "Production units", main = "De-Seasonalized Series") ## plotting the de-seasonlized data
```



ARIMA Modelling and Forecasting

ARIMA model

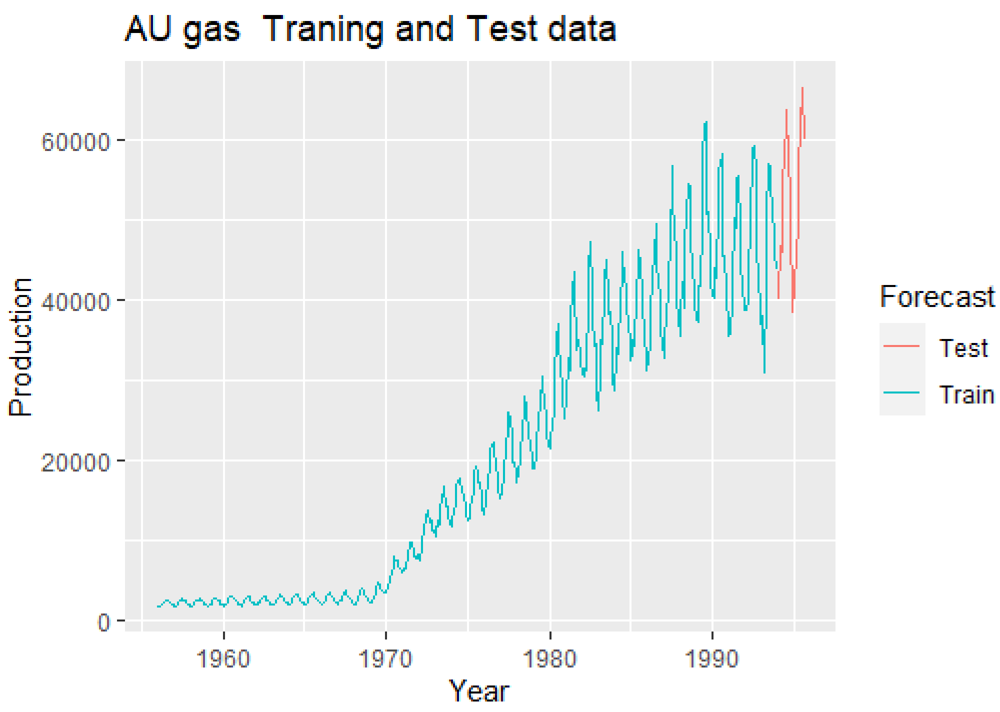
1. Before Forecasting method, we will need to split dataset into test and train data

Splitting dataset into Train and Test Data

```
train.AUgas = window(AU.gas, start=c(1956,1), end =
c(1993,12), frequency=12)
test.AUgas = window(AU.gas, start=c(1994,1), frequency=12)
```

Plotting the train and Test set

```
autoplot(train.AUgas, series="Train") +
autolayer(test.AUgas, series="Test") +
ggtitle("AU gas  Traning and Test data") +
xlab("Year") + ylab("Production") +
guides(colour=guide_legend(title="Forecast"))
```



ADF test proved that series is non-stationary. So as first step we will have to stationarize the series which can be done by differencing. This will be taken care by selecting d parameter in ARIMA[p,d,q] format modelling

Augas.diff = diff(AU.gas, differences = 2)

Testing whether series is stationary now by doing ADF test again on differenced data

adf.test(Augas.diff)

Warning in adf.test(Augas.diff): p-value smaller than printed p-value

Augmented Dickey-Fuller Test

data: Augas.diff
Dickey-Fuller = -17.029, Lag order = 7, p-value = 0.01
alternative hypothesis: stationary

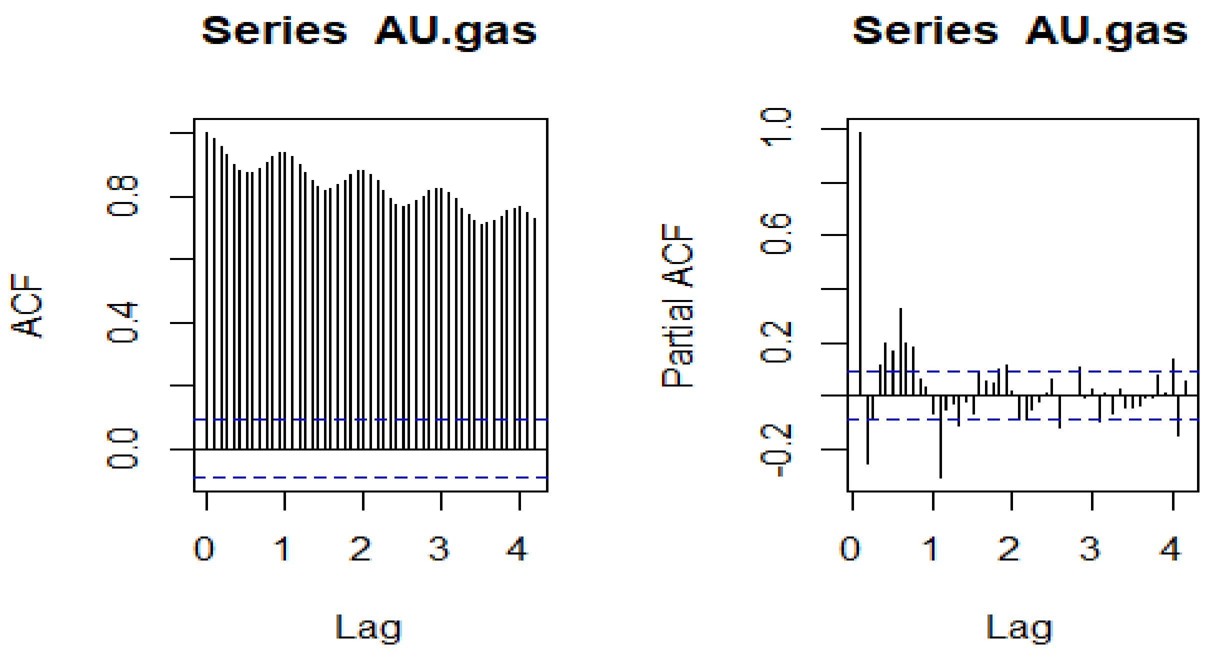
Since p-value suggested by test has gone down significantly we can say that differenced series AUgas.diff is stationary now. Differencing does make point in making series stationary

Checking ACF and PACF

Autocorrelation or ACF and Partial Autocorrelation PACF (after nullifying intermediary affects) of original time series AU gas dataset

ACF and PACF show the trended data observations and considerable significance upto very large lags for the original dataset of AU gas production

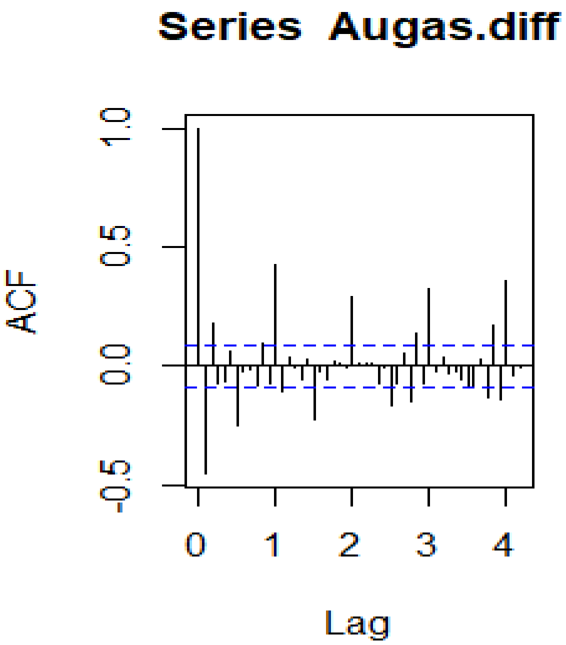
```
> par(mfrow=c(1,2))
> acf(AU.gas, lag.max = 50)
> pacf(AU.gas,lag.max = 50)
```

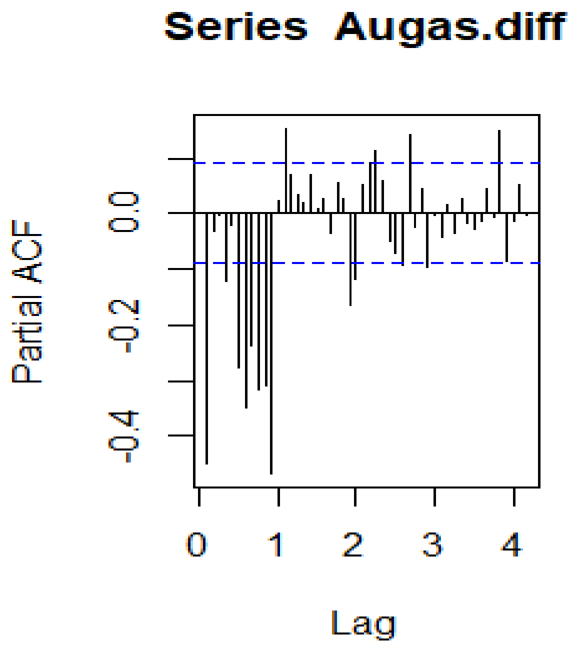


Autocorrelation or ACF and Partial Autocorrelation PACF (after nullifying intermediary affects) of Differenced time series AUdiff gas dataset

We observe that the correlations of lag 1, lag 2 are significant and so are Partial ACFs upto a very high lags

```
par(mfrow=c(1,2))
> acf(Augas.diff, lag.max = 50)
> pacf(Augas.diff,lag.max = 50)
```





Building a manual ARIMA[p,d,q] model with seasonal effects [P,D,Q]

- Model: ARIMA is defined by 3 parameters
- No of autoregressive terms
- No of differencing to stationarize the series
- No of moving average terms

```
> man.arima = arima(train.AUgas, order = c(1,1,1), seasonal =
c(1,1,1), method = 'ML')
> man.arima

Call:
arima(x = train.AUgas, order = c(1, 1, 1), seasonal = c(1, 1, 1),
method = "ML")

Coefficients:
         ar1      ma1    sar1     sma1
      0.3059  -0.7346  0.1202  -0.5929
s.e.  0.1174   0.0894  0.0944   0.0791

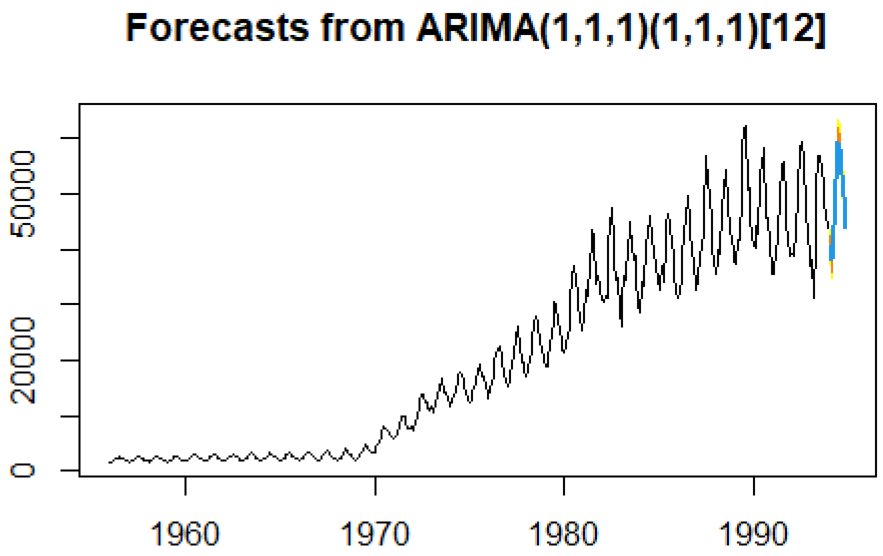
sigma^2 estimated as 2234482:  log likelihood = -3868.81,  aic
= 7747.61
```

AIC is 7747.61 ; Lower is considered better

Forecasting

Plotting the forecast of manual arima for 12 advance periods#

```
> par(mfrow=c(1,1))
> plot(forecast(man.arima, h=12), shadecols = "oldstyle")
```



For ARIMA model is assumed to be reasonable for a series, it is important to check whether the residuals are following white noise or not. Towards that goal Box-Ljung test is applied. **Box-Ljung test: This checks whether the residuals of time series data are stationary or not.**

H0: Residuals are stationary

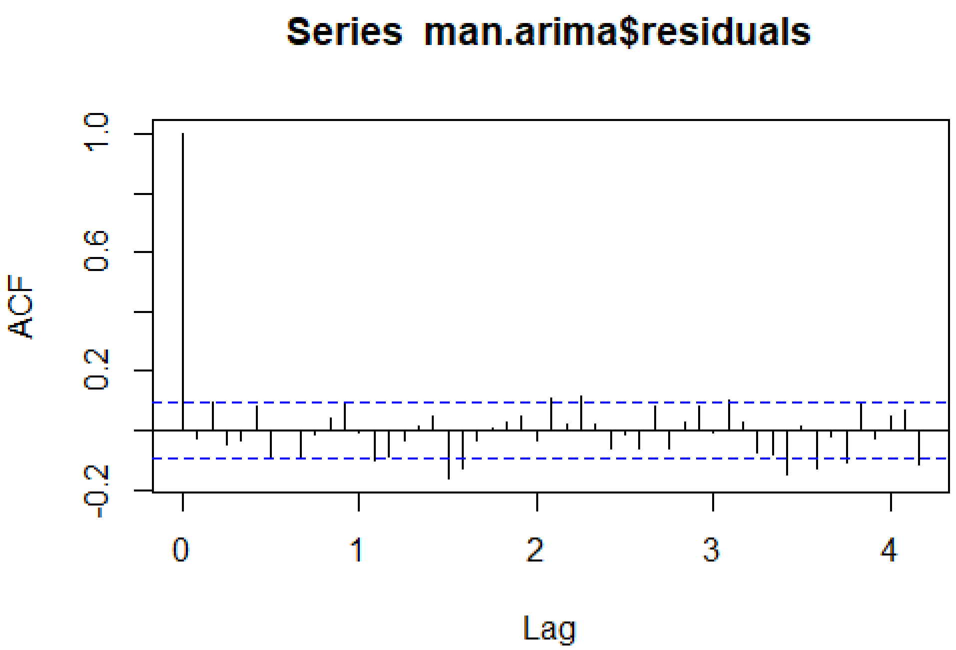
H1: Residuals are not stationary

```
Box.test(man.arima$residuals, type = "Ljung-Box", lag = 350)
```

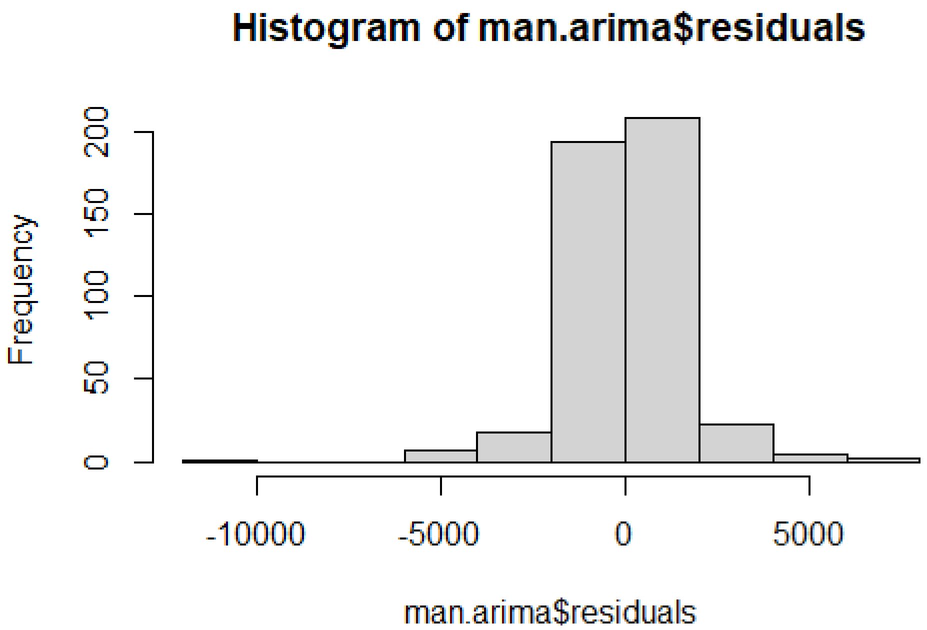
```
Box-Ljung test

data:  man.arima$residuals
X-squared = 360.79, df = 350, p-value = 0.3341
```

```
acf(man.arima$residuals, lag.max = 50)
```



hist(man.arima$residuals) ## checking the normal distribution of residuals



Purposefully taking a large lag value of 350 to display that p-value for hypothesis test is 0.3341 greater than significance level of 0.05 hence **we cannot reject the null hypothesis**

Auto ARIMA Model

We let auto arima decide on best parameters

```
> auto.fit = auto.arima(train.AUgas, trace = F, seasonal = T)
> auto.fit
```

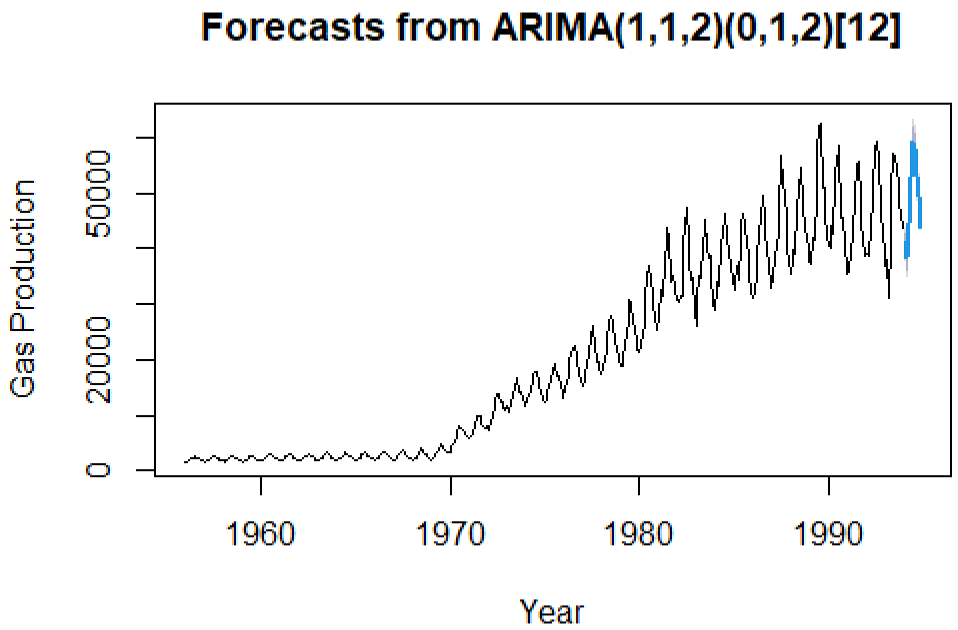
```
Series: train.AUgas
ARIMA(1,1,2)(0,1,2)[12]

Coefficients:
         ar1      ma1     ma2     sma1     sma2
      0.8310  -1.2848  0.3160  -0.4382  -0.0993
s.e.  0.0827   0.1098  0.0887   0.0535   0.0526

sigma^2 estimated as 2219950:  log likelihood=-3865.2
AIC=7742.4   AICc=7742.59   BIC=7766.96
```

Looks like auto modelling gives us p,d,q = 1,1,2 and seasonal order of P,D,Q ~= 0,1,2

```
plot(forecast(auto.fit, h=12), ylab = "Gas Production", xlab =
"Year")
```



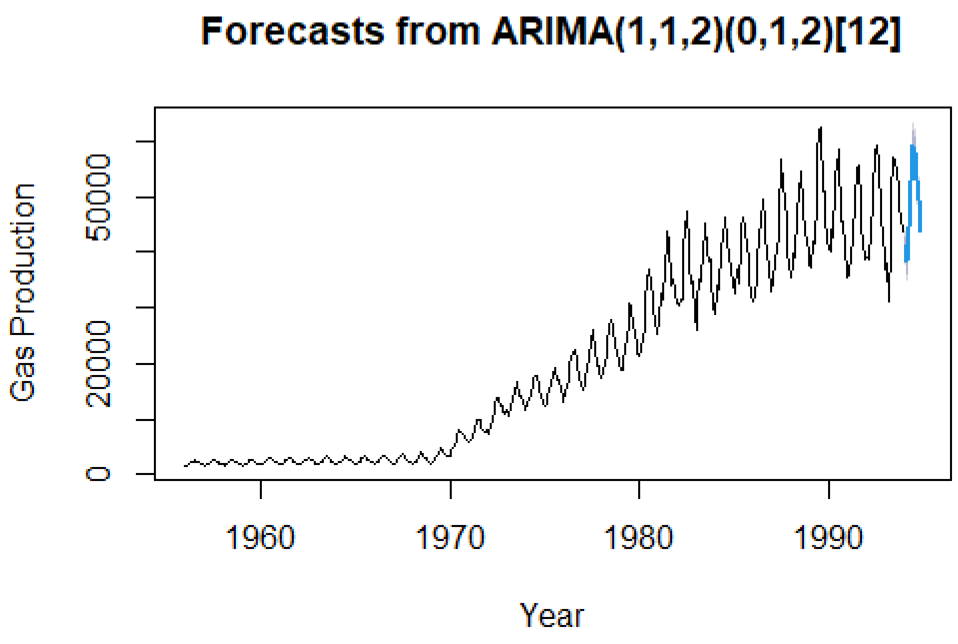
Box.test(auto.fit$residuals, type = "Ljung-Box", lag = 350)

Box-Ljung test

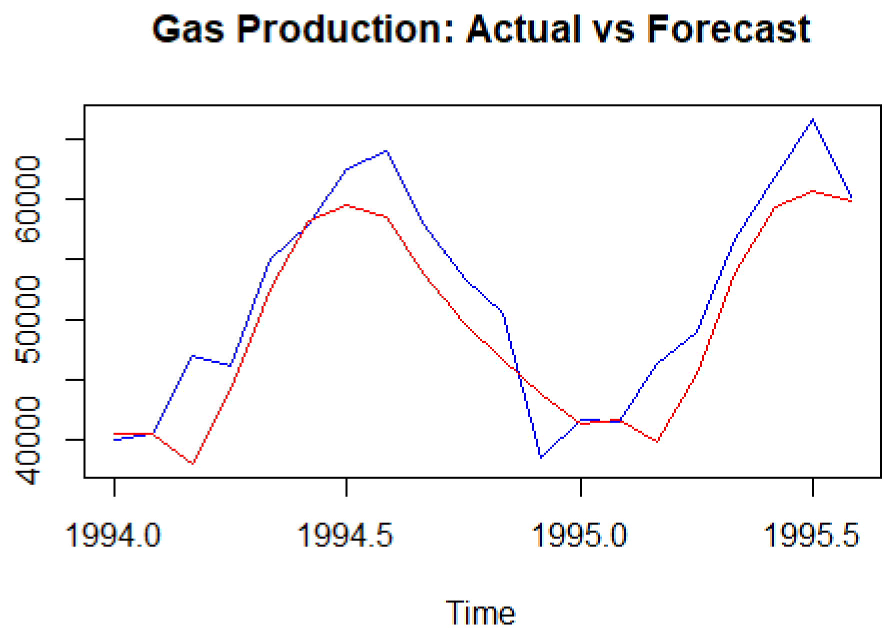
data: auto.fit$residuals
X-squared = 358.18, df = 350, p-value = 0.37

We check on the accuracy of our manual ARIMA model on our test data ie. test.AUgas Period from Jan-1994 to 1995 Aug

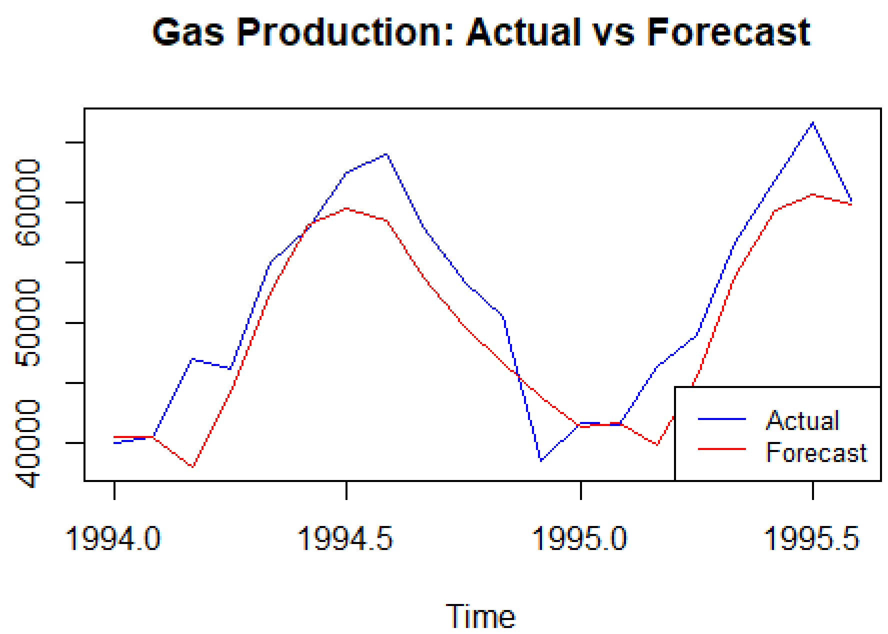
There is visible difference between modelled and actual values for the test period observations



Vec1<- cbind(test.AUgas ,as.data.frame(forecast(man.arima, h=20))[,1])
> ts.plot(Vec1, col=c("blue", "red"), main="Gas Production: Actual vs Forecast")



legend("bottomright", legend=c("Actual", "Forecast"),col=c("blue", "red"), cex=0.8, lty= 1:1)



Accuracy of the manual arima model###
> accuracy(forecast(man.arima, 24), test.AUgas)

```
                    ME     RMSE       MAE       MPE     MAPE
MASE        ACF1 Theil's U
Training set   13.17663 1473.357  848.3123 0.1274631
3.890809 0.4835891 -0.02465557        NA
Test set     2472.67931 3935.265 3094.7245 4.3989870
5.983214 1.7641795 -0.01304396 0.7843535
```

Accuracy of the Auto arima model###
accuracy(forecast(auto.fit, 24), test.AUgas)

```
                    ME     RMSE       MAE       MPE     MAPE
MASE         ACF1 Theil's U
Training set   21.00259 1460.247  845.3155 0.3948736
3.886841 0.4818808 -0.002459325        NA
Test set     2517.76019 3998.049 3220.9565 4.4221990
6.204546 1.8361394  0.008021776 0.7850042
```

Conclusion

We find that mostly the Manual Arima model is neck to neck in most of the accuracy parameters like

1. Root mean squared error
2. Mean absolute percentage error

But when it comes to actual model based on AIC Auto arima performs better giving 7742 against manual models 7747

We can always build a complex better fitting model by taking higher parameters. But such dependecy on the observations of long past such as in this case 1956 on 1995 is questionable as technology of gas exploration, its consumption and usage has gone up tremendously due to economic factors

We can improve model by dropping the long past observations and taking only the post 1970 era when a clear trend happens out

Appendix (R Code)

```
install.packages("forecast")
library(forecast)
library(tseries)
library(ggplot2)
library(kableExtra)
library(tseries)
data<-forecast::gas
print(data)
AU.gas=ts(data,start = c(1956,1),frequency = 12)
head(AU.gas)
tail(AU.gas)
class(AU.gas)
##Checking the Missing Values##
any(is.na(AU.gas))
##################
start(AU.gas)
end(AU.gas)
frequency(AU.gas)
summary(AU.gas)
cycle(AU.gas)

AU.gas.qtr=aggregate(AU.gas,nfrequency = 4)
AU.gas.yrly=aggregate(AU.gas,nfrequency = 1)
AU.gas.qtr
AU.gas.yrly

####Plots######
plot.ts(AU.gas,main="Monthly Gas Production 1956-
1995",xlab="Year", ylab="Gas Production")
plot.ts(AU.gas.qtr,main="Querterly Gas Production 1956-
1995",xlab="Year", ylab="Gas Production")
plot.ts(AU.gas.yrly,main="Yearly Gas Production 1956-
1995",xlab="Year", ylab="Gas Production")


####Seasonality Plot###
```

```
seasonplot(AU.gas, year.labels = TRUE, year.labels.left = TRUE,col =
1:40, pch=19,main = "Monthly Gas production - Seasonplot")
monthplot(AU.gas,main="Monthly Gas Production - Month
Plot",xlab="Month", ylab= "Gas Production")

####Boxplot
boxplot(AU.gas~cycle(AU.gas), main = "Monthly Gas Production - Box
Plot", xlab = "Month" , ylab = "Gas Production")

####Additive and Multiplicative model###
decompgas=decompose(AU.gas, type = "multiplicative")
plot(decompgas)
decompgas=decompose(AU.gas, type = "additive")
plot(decompgas)

decompgas
decompgas$seasonal
decompgas$trend
decompgas$random

####Plotting Individual#####
plot(decompgas$seasonal)
plot(decompgas$trend)
plot(decompgas$random)

output=(decompgas$trend+decompgas$random)
output_trend<-

  ####Using stl Function##########
  plot(stl(AU.gas, s.window = "periodic"))
AU.gas.ts2=stl(AU.gas, s.window = "periodic")
AU.gas.ts2

deseasongas=(AU.gas.ts2$time.series[,2]+AU.gas.ts2$time.series[,3])
ts.plot(deseasongas,AU.gas,col=c("red","blue"), main="comparison gas
production and deseasonalise gas production")



plot(stl(log(AU.gas), s.window = "periodic"))
```

```
AU.gas.ts3=stl(log(AU.gas), s.window = "periodic")
AU.gas.ts3$time.series[1:12,1]
AU.gas.ts3.season=exp(AU.gas.ts3$time.series[1:12,1])
plot(AU.gas.ts3.season,type = "l")

#Stationarity#
#Dicky Fuller test for Stationarity#
adf.test(AU.gas)

####Decomposing the Au series##
decomposed = stl(AU.gas, s.window = "periodic")
seasonal = decomposed$time.series[,1]
trend = decomposed$time.series[,2]
remainder = decomposed$time.series[,3]

#Removing the seasonality#
des.data = AU.gas - seasonal
plot(des.data, ylab= "Production units", main = "De-Seasonalized
Series") ## plotting the de-seasonlized data

#Splitting dataset into Train and Test data#
train.AUgas = window(AU.gas, start=c(1956,1), end = c(1993,12),
frequency=12)
test.AUgas = window(AU.gas, start=c(1994,1), frequency=12)
## Plotting the train and Test set
autoplot(train.AUgas, series="Train") +
  autolayer(test.AUgas, series="Test") +
  ggtitle("AU gas  Traning and Test data") +
  xlab("Year") + ylab("Production") +
  guides(colour=guide_legend(title="Forecast"))

Augas.diff = diff(AU.gas, differences = 2)
adf.test(Augas.diff)

#Checking ACF and PACF#
par(mfrow=c(1,2))
acf(AU.gas, lag.max = 50)
pacf(AU.gas,lag.max = 50)

par(mfrow=c(1,2))
```

```
acf(Augas.diff, lag.max = 50)
pacf(Augas.diff,lag.max = 50)

#Building a manual ARIMA[p,d,q] model with seasonal effects
[P,D,Q]#
man.arima = arima(train.AUgas, order = c(1,1,1), seasonal = c(1,1,1),
method = 'ML')
man.arima

#Forecasting#
### Plotting the forecast of manual arima for 12 advance periods#
par(mfrow=c(1,1))
plot(forecast(man.arima, h=12), shadecols = "oldstyle")
##########################################################
######
Box.test(man.arima$residuals, type = "Ljung-Box", lag = 350)
##################################################
acf(man.arima$residuals, lag.max = 50)
##############################################
hist(man.arima$residuals) ## checking the normal distribution of
residuals
###########################################

#Auto Arima Model#
auto.fit = auto.arima(train.AUgas, trace = F, seasonal = T)
auto.fit

plot(forecast(auto.fit, h=12), ylab = "Gas Production", xlab = "Year")
##########################################################
################

Box.test(auto.fit$residuals, type = "Ljung-Box", lag = 350)
##########################################################
###########

Vec1<- cbind(test.AUgas ,as.data.frame(forecast(man.arima, h=20))[,1])
ts.plot(Vec1, col=c("blue", "red"), main="Gas Production: Actual vs
Forecast")
legend("bottomright", legend=c("Actual", "Forecast"),col=c("blue",
"red"), cex=0.8, lty= 1:1)
```

```
### Accuracy of the manual arima model###
accuracy(forecast(man.arima, 24), test.AUgas)
#### Accuracy of the Auto arima model###
accuracy(forecast(auto.fit, 24), test.AUgas)

########################THANKYOU#######################
```