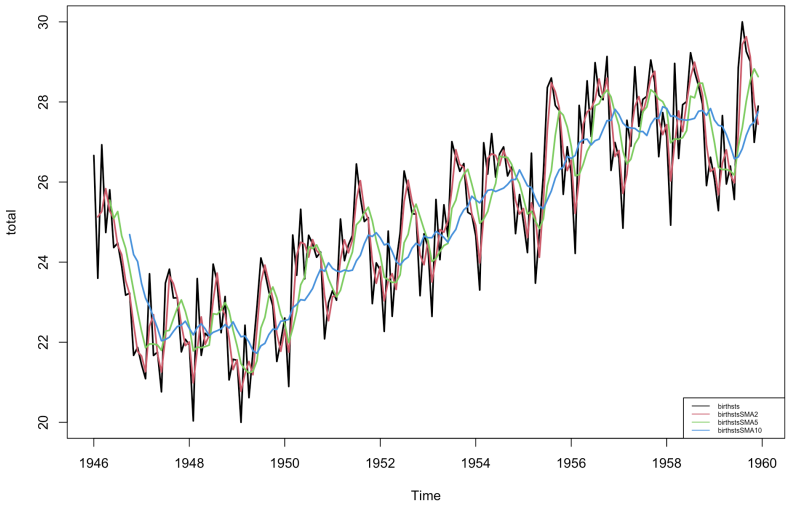
```
install.packages("TTR")
install.packages("forecast")
```

```
# Preliminary: ts
library("TTR")
a <- ts(1:20, frequency=12, start=c(2011,3))
print(a)
str(a)
attributes(a)
```

```
> # Preliminary: ts
> library("TTR")
> a <- ts(1:20, frequency=12, start=c(2011,3))
> print(a)
     Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
2011           1   2   3   4   5   6   7   8   9  10
2012  11  12  13  14  15  16  17  18  19  20
> str(a)
 Time-Series [1:20] from 2011 to 2013: 1 2 3 4 5 6 7 8 9 10 ...
> attributes(a)
$tsp
[1] 2011.167 2012.750   12.000

$class
[1] "ts"
```

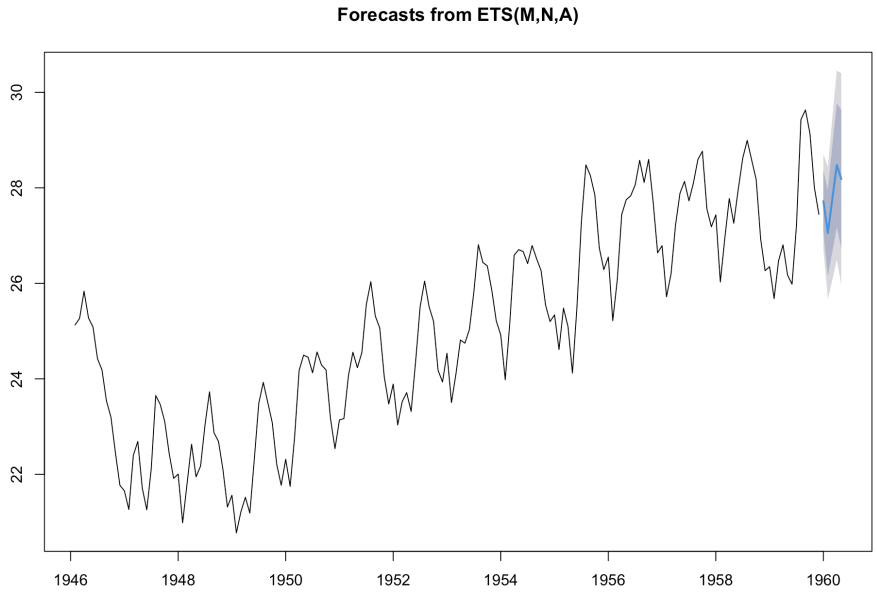
```
# Births Dataset
library("TTR")
births = read.csv("Desktop/exercises/Births.csv")
birthsts = ts(births[,2], frequency=12, start=c(1946,1))
birthstsSMA2 = SMA(birthsts,n=2)
birthstsSMA5 = SMA(birthsts,n=5)
birthstsSMA10 = SMA(birthsts,n=10)
total = cbind(birthsts,birthstsSMA2,birthstsSMA5,birthstsSMA10)
plot(total, plot.type="single",col = 1:ncol(total), lwd = c(2, 2, 2,2))
legend("bottomright", colnames(total), col=1:ncol(total), lty = c(1, 1, 1,1), cex=.5, y.intersp = 1)
```



```r
# Forecast using SMA
# To forecast using the same model
library("forecast")
birthstsSMA2
birthstsSMA2forecast = forecast(birthstsSMA2, h=5)
birthstsSMA2forecast
plot(birthstsSMA2forecast)
```

```
> birthstsSMA2
         Jan     Feb     Mar     Apr     May     Jun     Jul     Aug     Sep     Oct     Nov     Dec
1946      NA 25.1305 25.2645 25.8355 25.2730 25.0850 24.4205 24.1890 23.5380 23.2010 22.4495 21.7710
1947 21.6545 21.2640 22.3990 22.6890 21.7105 21.2565 22.1200 23.6515 23.4645 23.1075 22.4345 21.9160
1948 22.0050 20.9860 21.8125 22.6310 21.9470 22.1725 23.0365 23.7270 22.8710 22.6900 22.1005 21.3160
1949 21.5605 20.7740 21.2120 21.5195 21.1880 22.3175 23.4890 23.9260 23.5050 23.0845 22.2130 21.7720
1950 22.3145 21.7490 22.7855 24.1750 24.4965 24.4515 24.1270 24.5625 24.2880 24.1870 23.1680 22.5375
1951 23.1390 23.1680 24.0625 24.5565 24.2335 24.5485 25.5590 26.0345 25.3160 25.0620 24.0370 23.4725
1952 23.8895 23.0340 23.5225 23.7105 23.3170 24.3625 25.5065 26.0460 25.5130 25.2045 24.1805 23.9345
1953 24.5355 23.5040 24.1045 24.8135 24.7465 25.0330 25.8220 26.8075 26.4370 26.3650 25.8540 25.2130
1954 24.9185 23.9805 25.1430 26.5905 26.7045 26.6660 26.4140 26.7920 26.5150 26.2655 25.5455 25.2000
1955 25.3390 24.6145 25.4800 25.0980 24.1210 25.4930 27.2900 28.4800 28.2565 27.8490 26.7385 26.2870
1956 26.5490 25.2175 26.0660 27.4445 27.7510 27.8330 28.0605 28.5755 28.1125 28.5960 27.7135 26.6390
1957 26.7880 25.7185 26.1955 27.2195 27.8870 28.1340 27.7275 28.1030 28.5945 28.7660 27.5590 27.1845
1958 27.4335 26.0280 26.9435 27.7760 27.2600 27.9700 28.6190 28.9940 28.5820 28.1750 26.9285 26.2655
1959 26.3475 25.6810 26.4730 26.8055 26.1745 25.9815 27.2150 29.4325 29.6305 29.1365 28.0020 27.4445
```

```
> birthstsSMA2forecast
         Point Forecast    Lo 80    Hi 80    Lo 95    Hi 95
Jan 1960       27.72021 27.07512 28.36531 26.73363 28.70680
Feb 1960       27.05455 26.15311 27.95599 25.67591 28.43319
Mar 1960       27.76825 26.65902 28.87747 26.07183 29.46466
Apr 1960       28.47591 27.18368 29.76813 26.49962 30.45219
May 1960       28.18320 26.73390 29.63250 25.96668 30.39971
```



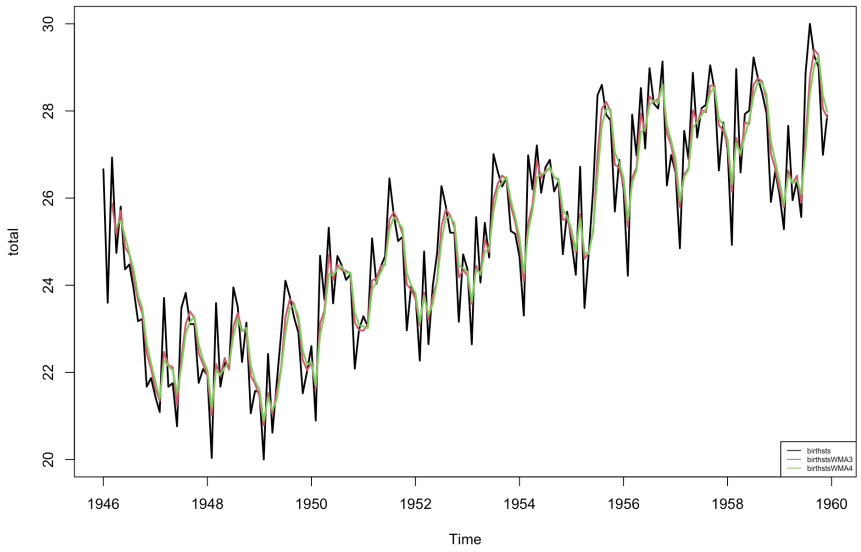
```
# Forecast Accuracy
accuracy(birthstsSMA2, birthsts)
```

```
> accuracy(birthstsSMA2, birthsts)
                    ME      RMSE       MAE          MPE     MAPE       ACF1 Theil's U
Test set 0.003694611 0.7526019 0.5976826 -0.07872341 2.399529 -0.5282228       0.5
```

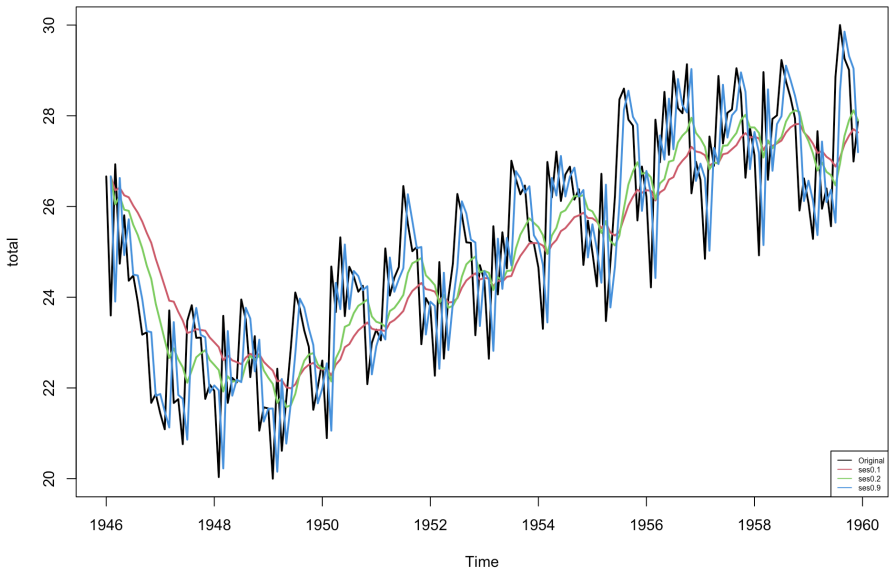
```
# WMA
xx <- c(.2,.3,.5)
birthstsWMA3 = WMA(birthsts, n=3, wts=xx)
birthstsWMA3
yy <- c(.1,.2,.3,.4)
birthstsWMA4 = WMA(birthsts, n=4, wts=yy)
birthstsWMA4
total = cbind(birthsts,birthstsWMA3,birthstsWMA4)
plot(total, plot.type="single",col = 1:ncol(total), lwd = c(2, 2, 2))
legend("bottomright", colnames(total),
         col=1:ncol(total), lty = c(1, 1, 1), cex=.5, y.intersp = 1)
```

```
> birthstsWMA3
         Jan     Feb     Mar     Apr     May     Jun     Jul     Aug     Sep     Oct     Nov     Dec
1946      NA      NA 25.8775 25.1689 25.7112 24.8718 24.7089 24.1664 23.6532 23.3462 22.4391 22.0820
1947 21.6149 21.3502 22.4690 22.1650 22.1185 21.2399 22.3182 23.1079 23.3955 23.2513 22.4335 22.1862
1948 21.9422 21.0132 22.1929 21.9200 22.3306 22.0625 23.0563 23.3616 22.9602 22.9432 21.9197 21.7326
1949 21.4577 20.7790 21.5216 21.0347 21.5498 22.0883 23.2664 23.6800 23.5762 23.1817 22.2840 22.0496
1950 22.2133 21.6332 23.1275 23.4184 24.6973 24.1221 24.4744 24.3449 24.3314 24.2534 23.1420 22.9711
1951 22.9576 23.1088 24.1101 24.1511 24.4413 24.4699 25.5116 25.6777 25.4826 25.1828 24.0178 23.9017
1952 23.6861 23.0706 23.8281 23.2095 23.7428 24.0941 25.3567 25.7382 25.6050 25.3257 24.1827 24.3419
1953 24.2265 23.5726 24.4485 24.2293 25.0471 24.7592 25.9812 26.3327 26.5176 26.4326 25.8152 25.4562
1954 24.9317 24.0851 25.4136 25.8549 26.8611 26.4638 26.6316 26.6752 26.4806 26.4107 25.5001 25.5334
1955 25.1438 24.7541 25.6302 24.6016 24.7702 25.2346 26.9996 28.0516 28.2089 27.9860 26.7645 26.7052
1956 26.3114 25.3503 26.4658 26.7053 27.9388 27.5226 28.3381 28.2069 28.2751 28.6186 27.4975 27.2080
1957 26.6488 25.7981 26.5437 26.6805 28.0164 27.7376 28.0251 27.9680 28.5793 28.5846 27.6718 27.5545
1958 27.2133 26.1486 27.3851 26.9682 27.7348 27.7016 28.6034 28.7500 28.6760 28.2458 27.0205 26.6721
1959 26.2061 25.7896 26.6310 26.3307 26.5163 25.8921 27.3816 28.7725 29.4035 29.2843 28.0518 27.8485
```

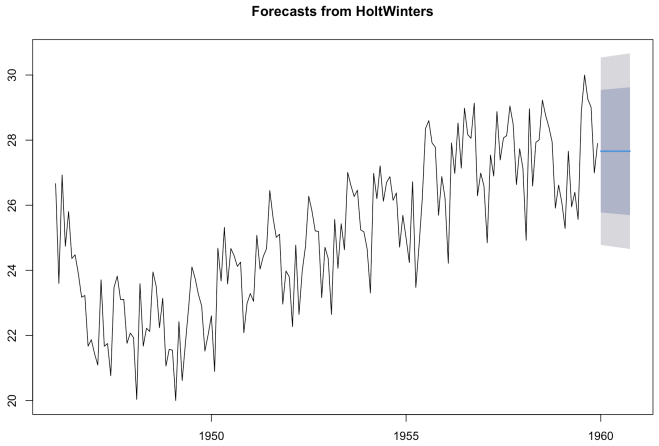
```
> birthstsWMA4
         Jan     Feb     Mar     Apr     May     Jun     Jul     Aug     Sep     Oct     Nov     Dec
1946      NA      NA      NA 25.3612 25.4904 25.1285 24.7352 24.3569 23.7721 23.4712 22.6620 22.2125
1947 21.7937 21.4085 22.2851 22.1420 22.0522 21.5347 22.1372 22.9007 23.1611 23.2882 22.6400 22.2894
1948 22.0595 21.1856 22.0412 21.9465 22.1119 22.2092 22.8285 23.2334 22.9487 23.0240 22.1642 21.7991
1949 21.6171 20.8849 21.4365 21.1280 21.3737 22.0433 22.9175 23.4813 23.5374 23.3014 22.5069 22.1733
1950 22.2436 21.6957 22.8623 23.3115 24.2547 24.2315 24.3746 24.4315 24.2775 24.2953 23.3790 23.0842
1951 23.0541 23.0123 23.9016 24.0761 24.3032 24.5108 25.2702 25.5589 25.4479 25.3169 24.2832 24.0050
1952 23.8173 23.1400 23.7487 23.3247 23.5710 24.0979 24.9937 25.5554 25.5577 25.4334 24.4481 24.3922
1953 24.3100 23.6244 24.3627 24.2595 24.7684 24.8522 25.6865 26.2152 26.3543 26.4873 25.9512 25.5650
1954 25.1122 24.2793 25.2334 25.7007 26.4705 26.5498 26.5809 26.7084 26.4776 26.4434 25.7167 25.5798
1955 25.2827 24.8014 25.5269 24.7531 24.7174 25.2848 26.5110 27.6684 28.0394 28.0437 27.0551 26.8085
1956 26.4681 25.4978 26.3625 26.6295 27.5079 27.6001 28.1374 28.2427 28.1834 28.6032 27.6853 27.3149
1957 26.9035 25.9424 26.4881 26.6498 27.6134 27.7529 27.9082 28.0417 28.4135 28.5427 27.8225 27.6858
1958 27.3485 26.3196 27.2623 27.0225 27.4341 27.7970 28.3394 28.6672 28.6364 28.3742 27.3052 26.8507
1959 26.3930 25.8522 26.5269 26.3432 26.4051 26.1016 27.0902 28.4123 29.0339 29.2696 28.3526 27.9849
```

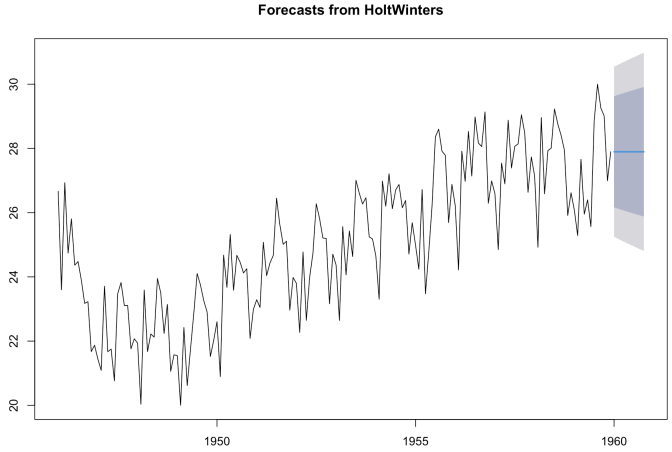


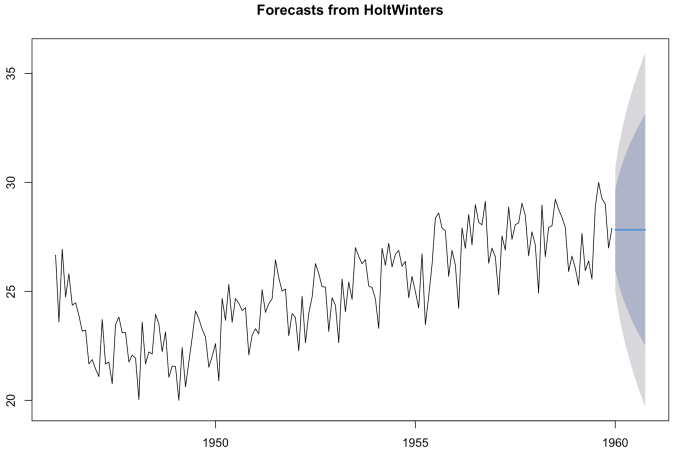
```r
# Single Exponential Smoothing
birthstssesa01 = HoltWinters(birthsts,alpha=0.1, beta=FALSE, gamma=FALSE)
birthstssesa02 = HoltWinters(birthsts,alpha=0.2, beta=FALSE, gamma=FALSE)
birthstssesa09 = HoltWinters(birthsts,alpha=0.9, beta=FALSE, gamma=FALSE)
total = cbind(birthsts,birthstssesa01$fitted[,1],birthstssesa02$fitted[,1],birthstssesa09$fitted[,1])
plot(total, plot.type="single", col = 1:ncol(total), lwd = c(2,2,2,2))
legend("bottomright", c("Original","ses0.1","ses0.2","ses0.9"), col=1:ncol(total), lty = c(1, 1), cex=.5,
       y.intersp = 1)
```



```r
# Single Exponential Smoothing Forecast
birthststssesforecast01 = forecast(birthststssesa01, h=10)
birthststssesforecast02 = forecast(birthststssesa02, h=10)
birthststssesforecast09 = forecast(birthststssesa09, h=10)
plot(birthststssesforecast01)
plot(birthststssesforecast02)
plot(birthststssesforecast09)

accuracy(birthststssesforecast01)
accuracy(birthststssesforecast02)
accuracy(birthststssesforecast09)
```

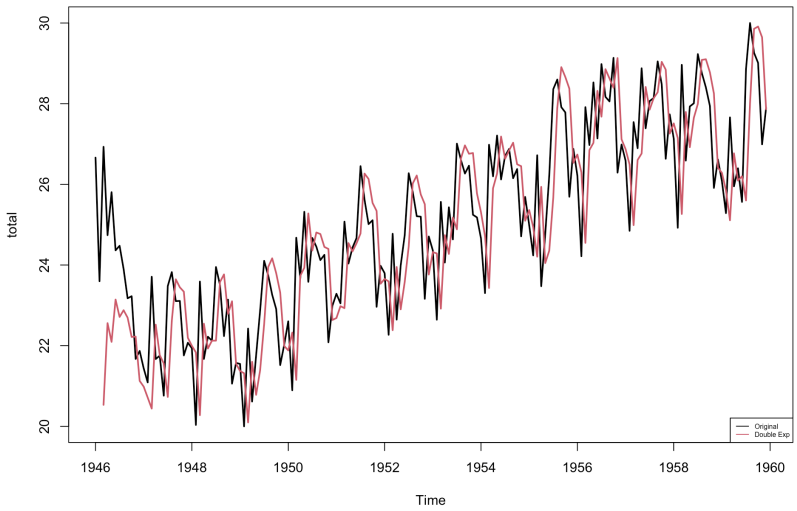




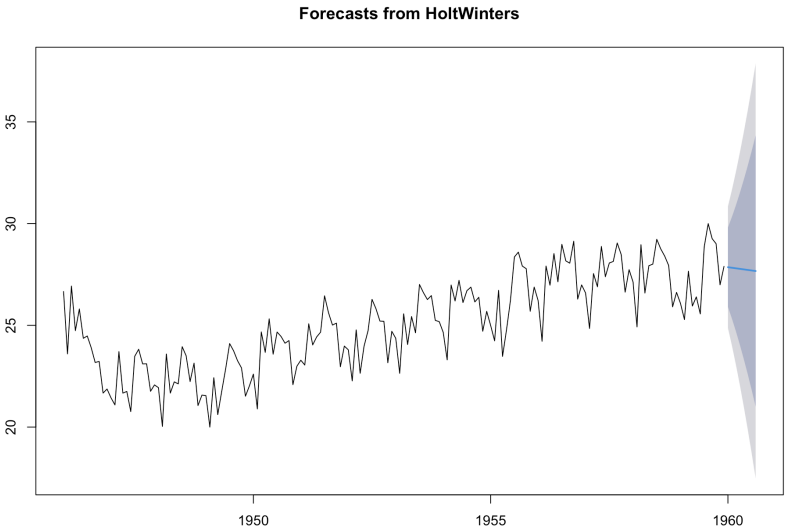


```
> accuracy(birthstssesforecast01)
                      ME     RMSE      MAE         MPE     MAPE     MASE      ACF1
Training set 0.05971923 1.46493 1.219158 -0.1149017 4.93054 1.289039 0.4175016
> accuracy(birthstssesforecast02)
                      ME     RMSE      MAE         MPE     MAPE     MASE     ACF1
Training set 0.03688771 1.346141 1.118519 -0.1295841 4.510113 1.182632 0.242625
> accuracy(birthstssesforecast09)
                      ME     RMSE      MAE         MPE     MAPE     MASE       ACF1
Training set 0.007744566 1.434287 1.124833 -0.1556807 4.515338 1.189308 -0.4568299
```

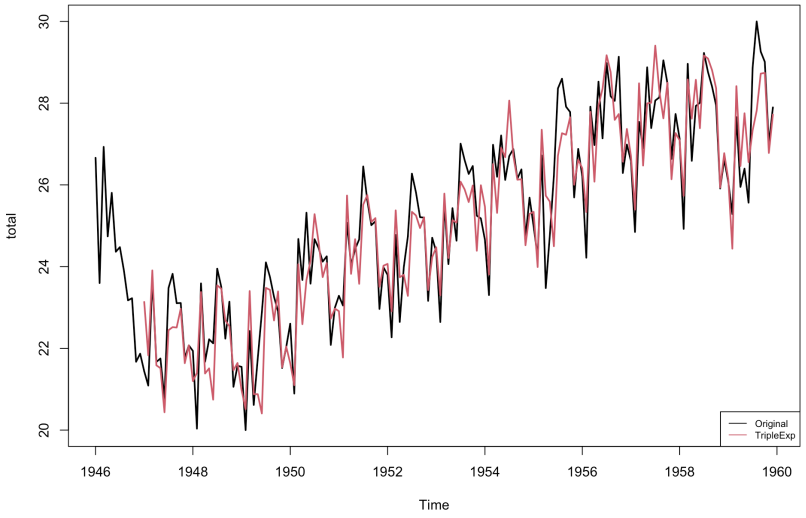
```
# Holt's Method - Double Exponential Smoothing
birthstsdep = HoltWinters(birthsts, gamma=FALSE)
total = cbind(birthsts,birthstsdep$fitted[,1])
plot(total,plot.type="single", col = 1:ncol(total), lwd = c(2, 2))
legend("bottomright", c("Original","Double Exp"), col=1:ncol(total), lty = c(1, 1), cex=.5, y.intersp = 1)
```



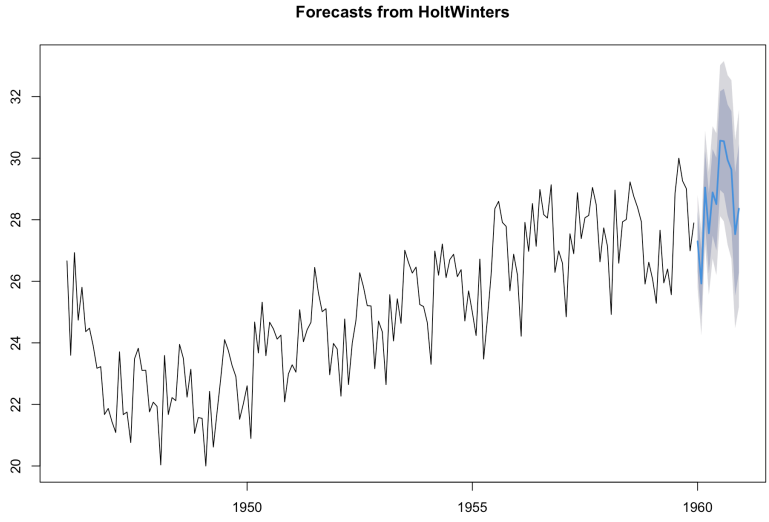
```
# Forecast - Holt's Method
birthstsdepforecast = forecast(birthstsdep, h=8)
plot(birthstsdepforecast)
```



```
# Winter's Method
birthststes= HoltWinters(birthsts)
total = cbind(birthsts,birthststes$fitted[,1])
plot(total, plot.type="single", col =
         1:ncol(total), lwd= c(2, 2))
         legend("bottomright", c("Original","TripleExp"), col=1:ncol(total), lty= c(1, 1), cex=.7, y.intersp= 1)
```



```
# Forecast: Winter's Method
library("forecast")
birthststes= HoltWinters(birthsts)
birthstesforecast = forecast(birthststes , h=12)
plot(birthstesforecast)
```

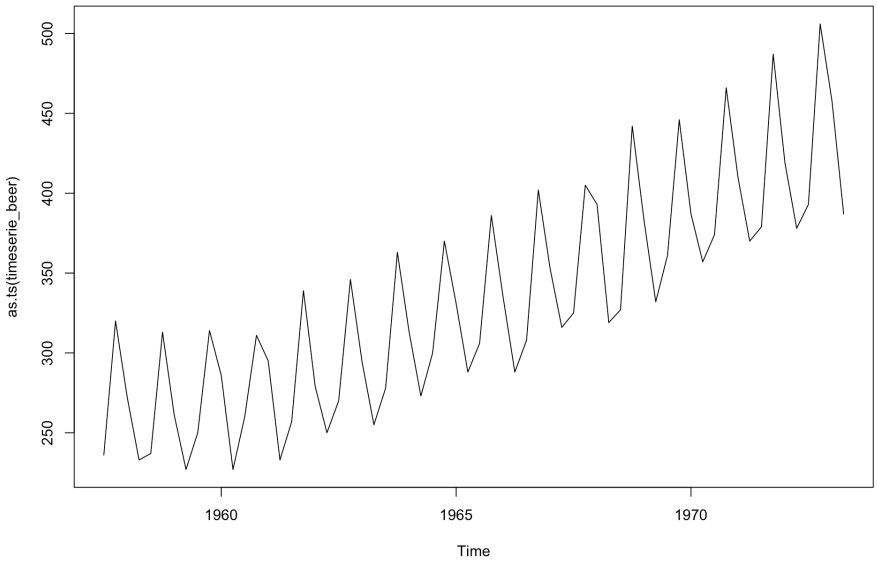


```
# Comparing DEP and TEP for births
accuracy(birthstsdep$fitted, birthsts)
accuracy(birthststes$fitted, birthsts)
```

```
> accuracy(birthstsdep$fitted, birthsts)
                ME     RMSE      MAE       MPE     MAPE        ACF1 Theil's U
Test set 0.1352527 1.525941 1.145695 0.3938218 4.573643 -0.08600271 0.9800669
> accuracy(birthststes$fitted, birthsts)
                ME      RMSE       MAE      MPE     MAPE      ACF1 Theil's U
Test set 0.08838484 0.7635132 0.5910602 0.307559 2.361872 0.3134715 0.4901279
```

```
# Steps in Decomposition Method
# 1. Plot the time series data
# 2. Identify time series model – Additive or Multiplicative
library(fpp)
data(ausbeer)
class(ausbeer)
ausbeer
timeserie_beer = tail(head(ausbeer, 70),64)
plot(as.ts(timeserie_beer))
```

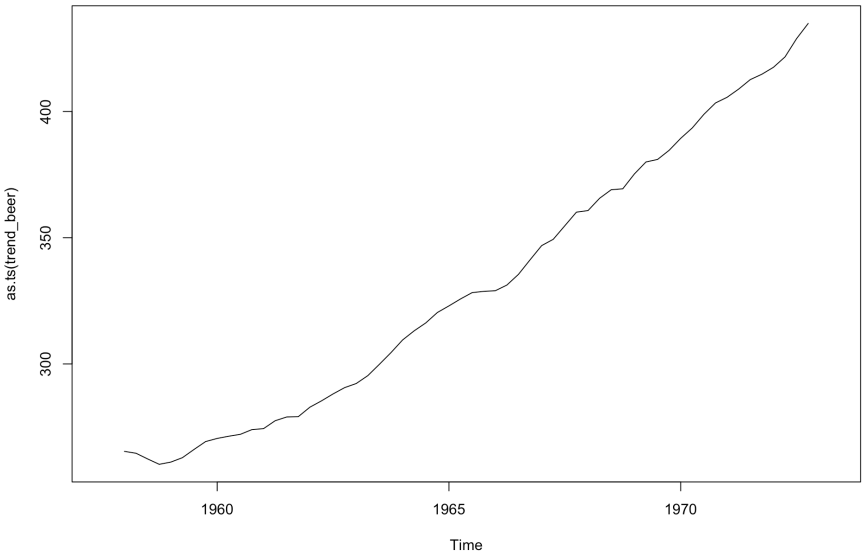
```
> class(ausbeer)
[1] "ts"
```



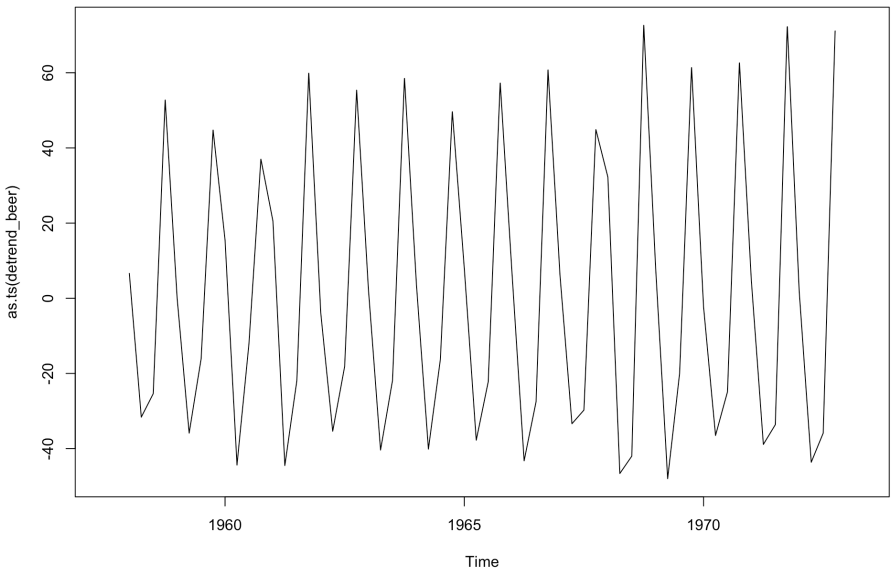
```
> ausbeer
     Qtr1 Qtr2 Qtr3 Qtr4
1956  284  213  227  308
1957  262  228  236  320
1958  272  233  237  313
1959  261  227  250  314
1960  286  227  260  311
1961  295  233  257  339
1962  279  250  270  346
1963  294  255  278  363
1964  313  273  300  370
1965  331  288  306  386
1966  335  288  308  402
1967  353  316  325  405
1968  393  319  327  442
1969  383  332  361  446
1970  387  357  374  466
1971  410  370  379  487
1972  419  378  393  506
1973  458  387  427  565
1974  465  445  450  556
1975  500  452  435  554
1976  510  433  453  548
1977  486  453  457  566
1978  515  464  431  588
1979  503  443  448  555
1980  513  427  473  526
1981  548  440  469  575
1982  493  433  480  576
1983  475  405  435  535
1984  453  430  417  552
1985  464  417  423  554
1986  459  428  429  534
1987  481  416  440  538
1988  474  440  447  598
1989  467  439  446  567
1990  485  441  429  599

1991  464  424  436  574
1992  443  410  420  532
1993  433  421  410  512
1994  449  381  423  531
1995  426  408  416  520
1996  409  398  398  507
1997  432  398  406  526
1998  428  397  403  517
1999  435  383  424  521
2000  421  402  414  500
2001  451  380  416  492
2002  428  408  406  506
2003  435  380  421  490
2004  435  390  412  454
2005  416  403  408  482
2006  438  386  405  491
2007  427  383  394  473
2008  420  390  410
```

```r
# 3. Detect the trend
# Here, MA used as smoother/trend detection
library(forecast)
trend_beer = ma(timeserie_beer, order=4, centre=T)
plot(as.ts(timeserie_beer))
lines(trend_beer)
plot(as.ts(trend_beer))
trend_beer
```

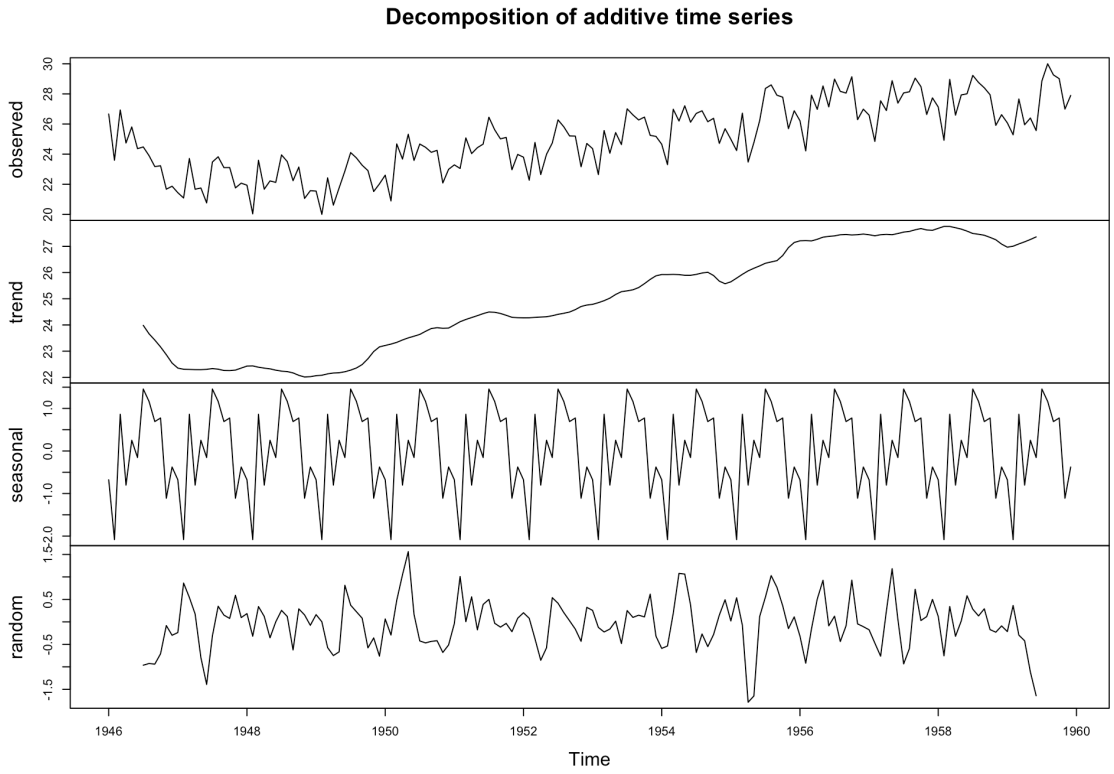
```
> trend_beer
        Qtr1    Qtr2    Qtr3    Qtr4
1957                      NA      NA
1958 265.375 264.625 262.375 260.250
1959 261.125 262.875 266.125 269.250
1960 270.500 271.375 272.125 274.000
1961 274.375 277.500 279.000 279.125
1962 282.875 285.375 288.125 290.625
1963 292.250 295.375 299.875 304.500
1964 309.500 313.125 316.250 320.375
1965 323.000 325.750 328.250 328.750
1966 329.000 331.250 335.500 341.250
1967 346.875 349.375 354.750 360.125
1968 360.750 365.625 369.000 369.375
1969 375.250 380.000 381.000 384.625
1970 389.375 393.500 398.875 403.375
1971 405.625 408.875 412.625 414.750
1972 417.500 421.625 428.875 434.875
1973      NA      NA
```



```r
# 4. De-trend the time series
detrend_beer = timeserie_beer - trend_beer
plot(as.ts(detrend_beer))
```



```r
# 5. Estimate the seasonality
# Decomposition 1
birthstimeseriescomponents <- decompose(birthsts)
plot(birthstimeseriescomponents)
birthstimeseriescomponents
```

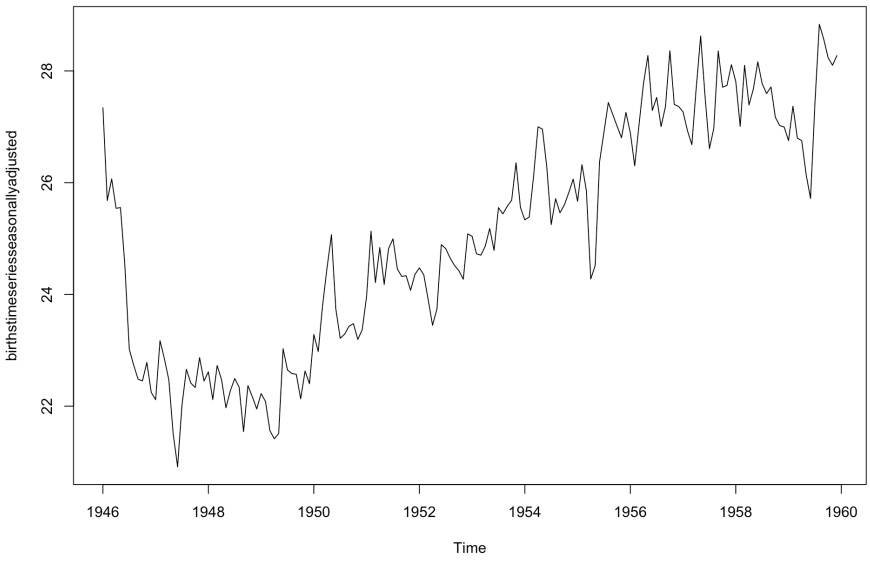


```
> birthstimeseriescomponents
$x
        Jan    Feb    Mar    Apr    May    Jun    Jul    Aug    Sep    Oct    Nov    Dec
1946 26.663 23.598 26.931 24.740 25.806 24.364 24.477 23.901 23.175 23.227 21.672 21.870
1947 21.439 21.089 23.709 21.669 21.752 20.761 23.479 23.824 23.105 23.110 21.759 22.073
1948 21.937 20.035 23.590 21.672 22.222 22.123 23.950 23.504 22.238 23.142 21.059 21.573
1949 21.548 20.000 22.424 20.615 21.761 22.874 24.104 23.748 23.262 22.907 21.519 22.025
1950 22.604 20.894 24.677 23.673 25.320 23.583 24.671 24.454 24.122 24.252 22.084 22.991
1951 23.287 23.049 25.076 24.037 24.430 24.667 26.451 25.618 25.014 25.110 22.964 23.981
1952 23.798 22.270 24.775 22.646 23.988 24.737 26.276 25.816 25.210 25.199 23.162 24.707
1953 24.364 22.644 25.565 24.062 25.431 24.635 27.009 26.606 26.268 26.462 25.246 25.180
1954 24.657 23.304 26.982 26.199 27.210 26.122 26.706 26.878 26.152 26.379 24.712 25.688
1955 24.990 24.239 26.721 23.475 24.767 26.219 28.361 28.599 27.914 27.784 25.693 26.881
1956 26.217 24.218 27.914 26.975 28.527 27.139 28.982 28.169 28.056 29.136 26.291 26.987
1957 26.589 24.848 27.543 26.896 28.878 27.390 28.065 28.141 29.048 28.484 26.634 27.735
1958 27.132 24.924 28.963 26.589 27.931 28.009 29.229 28.759 28.405 27.945 25.912 26.619
1959 26.076 25.286 27.660 25.951 26.398 25.565 28.865 30.000 29.261 29.012 26.992 27.897

$seasonal
            Jan        Feb        Mar        Apr        May        Jun       Jul       Aug       Sep       Oct        Nov        Dec
1946 -0.6771947 -2.0829607  0.8625232 -0.8016787  0.2516514 -0.1532556 1.4560457 1.1645938 0.6916162 0.7752444 -1.1097652 -0.3768197
1947 -0.6771947 -2.0829607  0.8625232 -0.8016787  0.2516514 -0.1532556 1.4560457 1.1645938 0.6916162 0.7752444 -1.1097652 -0.3768197
1948 -0.6771947 -2.0829607  0.8625232 -0.8016787  0.2516514 -0.1532556 1.4560457 1.1645938 0.6916162 0.7752444 -1.1097652 -0.3768197
1949 -0.6771947 -2.0829607  0.8625232 -0.8016787  0.2516514 -0.1532556 1.4560457 1.1645938 0.6916162 0.7752444 -1.1097652 -0.3768197
1950 -0.6771947 -2.0829607  0.8625232 -0.8016787  0.2516514 -0.1532556 1.4560457 1.1645938 0.6916162 0.7752444 -1.1097652 -0.3768197
1951 -0.6771947 -2.0829607  0.8625232 -0.8016787  0.2516514 -0.1532556 1.4560457 1.1645938 0.6916162 0.7752444 -1.1097652 -0.3768197
1952 -0.6771947 -2.0829607  0.8625232 -0.8016787  0.2516514 -0.1532556 1.4560457 1.1645938 0.6916162 0.7752444 -1.1097652 -0.3768197
1953 -0.6771947 -2.0829607  0.8625232 -0.8016787  0.2516514 -0.1532556 1.4560457 1.1645938 0.6916162 0.7752444 -1.1097652 -0.3768197
1954 -0.6771947 -2.0829607  0.8625232 -0.8016787  0.2516514 -0.1532556 1.4560457 1.1645938 0.6916162 0.7752444 -1.1097652 -0.3768197
1955 -0.6771947 -2.0829607  0.8625232 -0.8016787  0.2516514 -0.1532556 1.4560457 1.1645938 0.6916162 0.7752444 -1.1097652 -0.3768197
1956 -0.6771947 -2.0829607  0.8625232 -0.8016787  0.2516514 -0.1532556 1.4560457 1.1645938 0.6916162 0.7752444 -1.1097652 -0.3768197
1957 -0.6771947 -2.0829607  0.8625232 -0.8016787  0.2516514 -0.1532556 1.4560457 1.1645938 0.6916162 0.7752444 -1.1097652 -0.3768197
1958 -0.6771947 -2.0829607  0.8625232 -0.8016787  0.2516514 -0.1532556 1.4560457 1.1645938 0.6916162 0.7752444 -1.1097652 -0.3768197
1959 -0.6771947 -2.0829607  0.8625232 -0.8016787  0.2516514 -0.1532556 1.4560457 1.1645938 0.6916162 0.7752444 -1.1097652 -0.3768197

$trend
          Jan       Feb       Mar       Apr       May       Jun       Jul       Aug       Sep       Oct       Nov       Dec
1946       NA        NA        NA        NA        NA        NA 23.98433 23.66213 23.42333 23.16112 22.86425 22.54521
1947 22.35350 22.30871 22.30258 22.29479 22.29354 22.30562 22.33483 22.31167 22.26279 22.25796 22.27767 22.35400
1948 22.43038 22.43667 22.38721 22.35242 22.32458 22.27458 22.23754 22.21988 22.16983 22.07721 22.01396 22.02604
1949 22.06375 22.08033 22.13317 22.16604 22.17542 22.21342 22.27625 22.35750 22.48862 22.70992 22.98563 23.16346
1950 23.21663 23.26967 23.33492 23.42679 23.50638 23.57017 23.63888 23.75713 23.86354 23.89533 23.87342 23.88150
1951 24.00083 24.12350 24.20917 24.28208 24.35450 24.43242 24.49496 24.48379 24.43879 24.36829 24.29192 24.27642
1952 24.27204 24.27300 24.28942 24.30129 24.31325 24.35175 24.40558 24.44475 24.49325 24.58517 24.70429 24.76017
1953 24.78646 24.84992 24.92692 25.02362 25.16308 25.26963 25.30154 25.34125 25.42779 25.57588 25.73904 25.87513
1954 25.92446 25.92317 25.92967 25.92137 25.89567 25.89458 25.92963 25.98246 26.01054 25.88617 25.67087 25.57312
1955 25.64612 25.78679 25.93192 26.06388 26.16329 26.25388 26.35471 26.40496 26.45379 26.64933 26.95183 27.14683
1956 27.21104 27.21900 27.20700 27.26925 27.35050 27.37983 27.39975 27.44150 27.45229 27.43354 27.44488 27.46996
1957 27.44221 27.40283 27.44300 27.45717 27.44429 27.48975 27.54354 27.56933 27.63167 27.67804 27.62579 27.61212
1958 27.68642 27.76067 27.75963 27.71037 27.65783 27.58125 27.49075 27.46183 27.42262 27.34175 27.25129 27.08558
1959 26.96858 27.00512 27.09250 27.17263 27.26208 27.36033       NA       NA       NA       NA       NA       NA
```

```
$random
             Jan          Feb          Mar          Apr          May          Jun          Jul          Aug          Sep          Oct          Nov
1946          NA           NA           NA           NA           NA           NA -0.963379006 -0.925718750 -0.939949519 -0.709369391 -0.082484776
1947 -0.237305288  0.863252404  0.543893429  0.175887019 -0.793193109 -1.391369391 -0.311879006  0.347739583  0.150592147  0.076797276  0.591098558
1948  0.183819712 -0.318705929  0.340268429  0.121262019 -0.354234776  0.001672276  0.256412660  0.119531250 -0.623449519  0.289547276  0.154806891
1949  0.161444712  0.002627404 -0.571689904 -0.749362981 -0.666068109  0.813838942  0.371704327  0.225906250  0.081758814 -0.578161058 -0.356859776
1950  0.064569712 -0.292705929  0.479560096  1.047887019  1.561973558  0.166088942 -0.423920673 -0.467718750 -0.433157853 -0.418577724 -0.679651442
1951 -0.036638622  1.008460737  0.004310096  0.556595353 -0.176151442  0.387838942  0.499995994 -0.030385417 -0.116407853 -0.033536058 -0.218151442
1952  0.203153045  0.079960737 -0.376939904 -0.853612981 -0.576901442  0.538505609  0.414370994  0.206656250  0.025133814 -0.161411058 -0.432526442
1953  0.254736378 -0.122955929 -0.224439904 -0.159946314  0.016265224 -0.481369391  0.251412660  0.100156250  0.148592147  0.110880609  0.616723558
1954 -0.590263622 -0.536205929  0.189810096  1.079303686  1.062681891  0.380672276 -0.679670673 -0.269052083 -0.550157853 -0.282411058  0.150890224
1955  0.021069712  0.535169071 -0.073439904 -1.787196314 -1.647943109  0.118380609  0.550245994  1.029447917  0.768592147  0.359422276 -0.149068109
1956 -0.316846955 -0.918039263 -0.155523237  0.507428686  0.924848558 -0.087577724  0.126204327 -0.437093750 -0.087907853  0.927213942 -0.044109776
1957 -0.176013622 -0.471872596 -0.762523237  0.240512019  1.182056891  0.053505609 -0.934587340 -0.592927083  0.724717147  0.030713942  0.117973558
1958  0.122778045 -0.753705929  0.340851763 -0.319696314  0.021515224  0.581005609  0.282204327  0.132572917  0.290758814 -0.171994391 -0.229526442
1959 -0.215388622  0.363835737 -0.295023237 -0.419946314 -1.115734776 -1.642077724           NA           NA           NA           NA           NA

              Dec
1946 -0.298388622
1947  0.095819712
1948 -0.076221955
1949 -0.761638622
1950 -0.513680288
1951  0.081403045
1952  0.323653045
1953 -0.318305288
1954  0.491694712
1955  0.110986378
1956 -0.106138622
1957  0.499694712
1958 -0.089763622
1959           NA

$figure
 [1] -0.6771947 -2.0829607  0.8625232 -0.8016787  0.2516514 -0.1532556  1.4560457  1.1645938  0.6916162  0.7752444 -1.1097652 -0.3768197

$type
[1] "additive"

attr(,"class")
[1] "decomposed.ts"
```

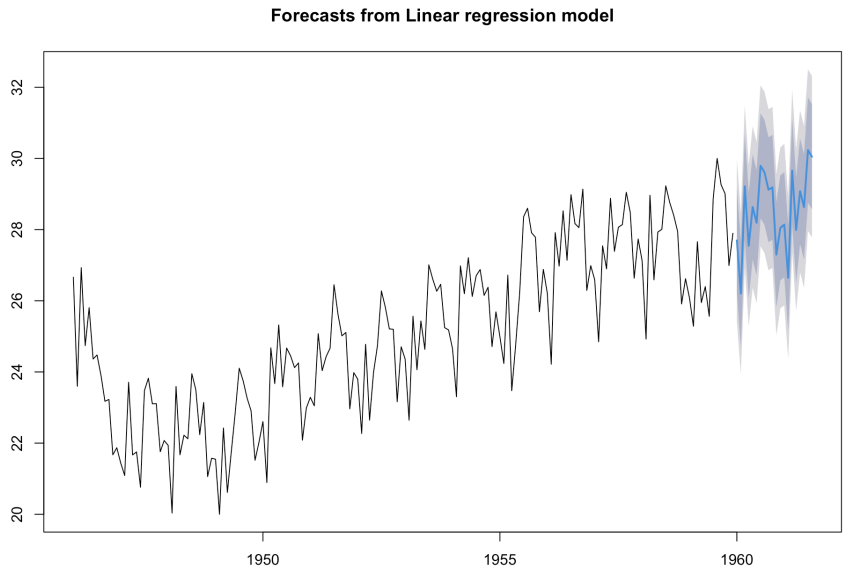
```r
# Seasonal Adjustment Decomposition 1
birthstimeseriescomponents <- decompose(birthsts)
birthstimeseriesseasonallyadjusted <- birthsts - birthstimeseriescomponents$seasonal
birthstimeseriesseasonallyadjusted
plot(birthstimeseriesseasonallyadjusted)
```

```
> birthstimeseriesseasonallyadjusted
          Jan      Feb      Mar      Apr      May      Jun      Jul      Aug      Sep      Oct      Nov      Dec
1946 27.34019 25.68096 26.06848 25.54168 25.55435 24.51726 23.02095 22.73641 22.48338 22.45176 22.78177 22.24682
1947 22.11619 23.17196 22.84648 22.47068 21.50035 20.91426 22.02295 22.65941 22.41338 22.33476 22.86877 22.44982
1948 22.61419 22.11796 22.72748 22.47368 21.97035 22.27626 22.49395 22.33941 21.54638 22.36676 22.16877 21.94982
1949 22.22519 22.08296 21.56148 21.41668 21.50935 23.02726 22.64795 22.58341 22.57038 22.13176 22.62877 22.40182
1950 23.28119 22.97696 23.81448 24.47468 25.06835 23.73626 23.21495 23.28941 23.43038 23.47676 23.19377 23.36782
1951 23.96419 25.13196 24.21348 24.83868 24.17835 24.82026 24.99495 24.45341 24.32238 24.33476 24.07377 24.35782
1952 24.47519 24.35296 23.91248 23.44768 23.73635 24.89026 24.81995 24.65141 24.51838 24.42376 24.27177 25.08382
1953 25.04119 24.72696 24.70248 24.86368 25.17935 24.78826 25.55295 25.44141 25.57638 25.68676 26.35577 25.55682
1954 25.33419 25.38696 26.11948 27.00068 26.95835 26.27526 25.24995 25.71341 25.46038 25.60376 25.82177 26.06482
1955 25.66719 26.32196 25.85848 24.27668 24.51535 26.37226 26.90495 27.43441 27.22238 27.00876 26.80277 27.25782
1956 26.89419 26.30096 27.05148 27.77668 28.27535 27.29226 27.52595 27.00441 27.36438 28.36076 27.40077 27.36382
1957 27.26619 26.93096 26.68048 27.69768 28.62635 27.54326 26.60895 26.97641 28.35638 27.70876 27.74377 28.11182
1958 27.80919 27.00696 28.10048 27.39068 27.67935 28.16226 27.77295 27.59441 27.71338 27.16976 27.02177 26.99582
1959 26.75319 27.36896 26.79748 26.75268 26.14635 25.71826 27.40895 28.83541 28.56938 28.23676 28.10177 28.27382
```

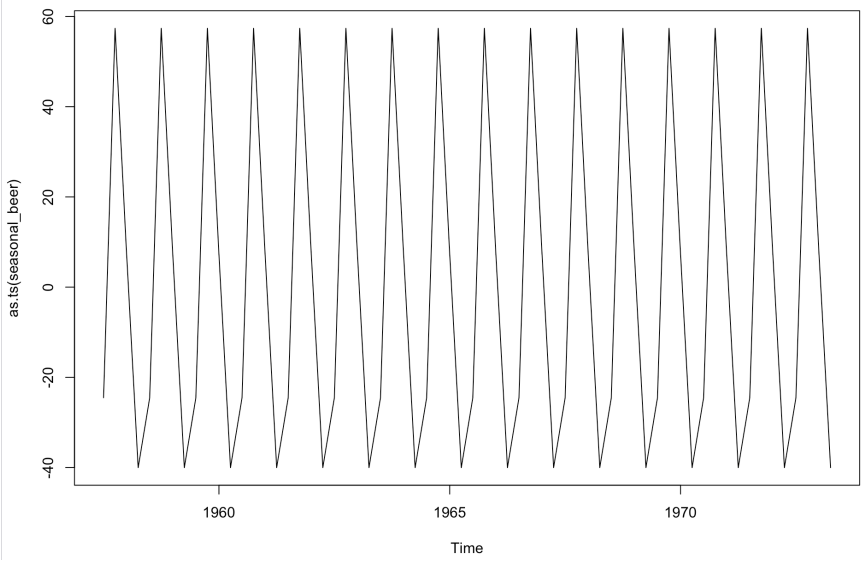


```r
# Decomposition 2
fit = tslm(birthsts~trend + season)
summary(fit)
plot(forecast(fit, h=20))
```

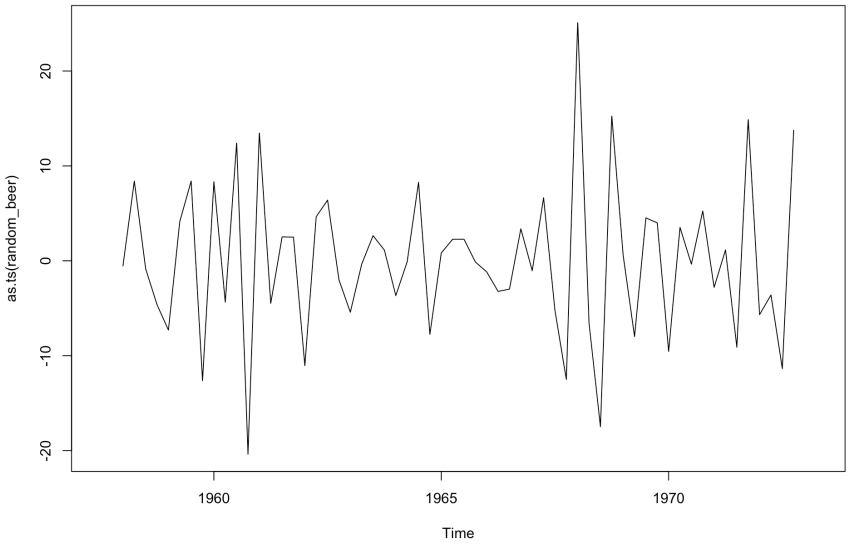
```
> summary(fit)

Call:
tslm(formula = birthsts ~ trend + season)

Residuals:
    Min      1Q  Median      3Q     Max
-2.1819 -0.5458 -0.1180  0.4999  5.1607

Coefficients:
             Estimate Std. Error t value Pr(>|t|)
(Intercept) 21.465397   0.323663  66.320  < 2e-16 ***
trend        0.036877   0.001747  21.108  < 2e-16 ***
season2     -1.529948   0.414028  -3.695 0.000304 ***
season3      1.442604   0.414039   3.484 0.000642 ***
season4     -0.260772   0.414058  -0.630 0.529755
season5      0.789637   0.414084   1.907 0.058377 .
season6      0.307546   0.414117   0.743 0.458815
season7      1.873312   0.414157   4.523  1.2e-05 ***
season8      1.650150   0.414205   3.984 0.000104 ***
season9      1.128488   0.414260   2.724 0.007188 **
season10     1.157254   0.414323   2.793 0.005879 **
season11    -0.768908   0.414393  -1.856 0.065423 .
season12    -0.055213   0.414470  -0.133 0.894197
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Residual standard error: 1.095 on 155 degrees of freedom
Multiple R-squared:  0.7929,    Adjusted R-squared:  0.7768
F-statistic: 49.44 on 12 and 155 DF,  p-value: < 2.2e-16
```



```r
# Seasonal beer
decomposition_beer <- decompose(timeserie_beer)
seasonal_beer <- decomposition_beer$seasonal
plot(as.ts(seasonal_beer))
```



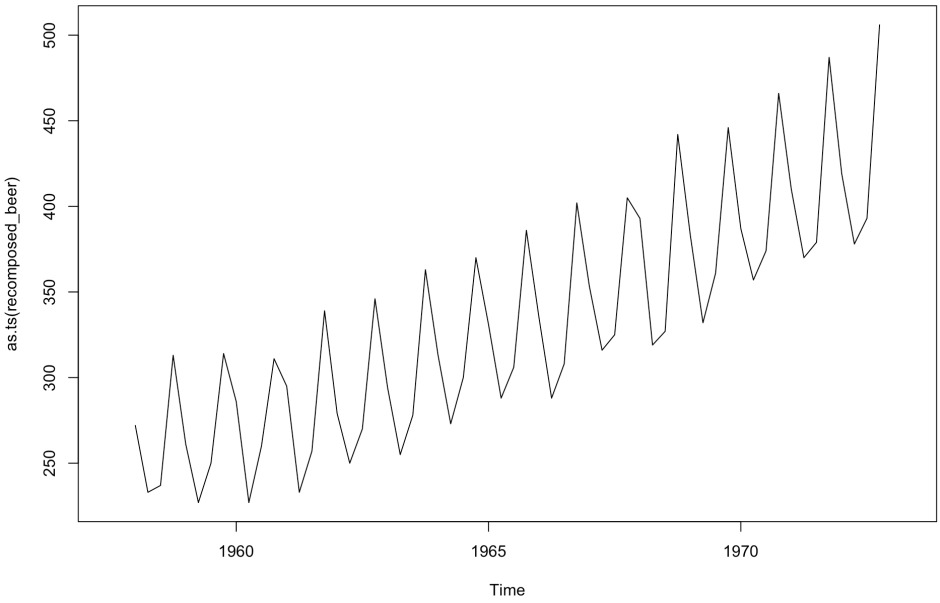
```r
# 6. Examine irregular and random variations
# Examine irregular and random variations
random_beer = timeserie_beer - trend_beer - seasonal_beer
plot(as.ts(random_beer))
```



```r
# 7. Reconstruct original time series
# Reconstruct original time series
recomposed_beer = trend_beer+seasonal_beer+random_beer
recomposed_beer
recomposed_beer - ausbeer
plot(as.ts(recomposed_beer))
```

```
> recomposed_beer
     Qtr1 Qtr2 Qtr3 Qtr4
1957                 NA   NA
1958  272  233  237  313
1959  261  227  250  314
1960  286  227  260  311
1961  295  233  257  339
1962  279  250  270  346
1963  294  255  278  363
1964  313  273  300  370
1965  331  288  306  386
1966  335  288  308  402
1967  353  316  325  405
1968  393  319  327  442
1969  383  332  361  446
1970  387  357  374  466
1971  410  370  379  487
1972  419  378  393  506
1973   NA   NA
```

```
> recomposed_beer - ausbeer
     Qtr1 Qtr2 Qtr3 Qtr4
1957                 NA   NA
1958    0    0    0    0
1959    0    0    0    0
1960    0    0    0    0
1961    0    0    0    0
1962    0    0    0    0
1963    0    0    0    0
1964    0    0    0    0
1965    0    0    0    0
1966    0    0    0    0
1967    0    0    0    0
1968    0    0    0    0
1969    0    0    0    0
1970    0    0    0    0
1971    0    0    0    0
1972    0    0    0    0
1973   NA   NA
```


as.ts(recomposed_beer)
250
300
350
400
450
500
1960
1965
1970
Time