Mining Time Series Data

Hazim Fitri

2024-12-08

Contents

4 main topics in time series

- Decompose
- Forecast
- Clustering
- Classification

1. Convert any data type into “Date” data type ISO 8601

1. %Y = 4 digit year (2000)
2. %y = 2 digit year (00)
3. %m = 2 digit month (12)
4. %B = month (December)
5. %b = abbreviated month (Dec)
6. %d = 2 digit day (03)
7. %A = day (Sunday)
8. %a = abbreviated day (Sun)

```
Sys.Date()
```

```
## [1] "2025-02-21"
```

```
sample_data <- rnorm(60)
ts(sample_data, start=c(2020,2), frequency = 12)
```

```
##              Jan         Feb         Mar         Apr         May         Jun
## 2020             -0.81729056 -0.34778997  0.59233714  0.49137678  0.27471254
## 2021 -1.02588956 -0.77874175  0.41722634  0.01798048 -0.48242790 -0.77363858
## 2022 -0.11193833 -0.84700700  0.81132047  0.77792424 -0.28809030 -1.30653035
## 2023 -1.85716477  0.25766724 -0.93915863 -0.78058359  0.26471571  1.46379755
## 2024 -1.62552421 -0.26811916  1.78390873 -0.53745084  0.35969933 -0.08695137
## 2025  0.39513421
##              Jul         Aug         Sep         Oct         Nov         Dec
## 2020  0.69338908 -0.25732703 -1.15688042  1.02531125  1.19856791 -1.39291718
## 2021  0.07256023  0.12138431  0.15041576 -0.47906350  0.11932798  0.33055840
## 2022 -0.64654454 -0.24168459  0.14027031  1.98914866 -0.82253047  0.80250887
## 2023  1.30524499  1.63267428 -0.21937397 -0.26890682 -1.23664317 -0.03369356
## 2024 -0.84653998 -0.53562852  1.27502560  1.57720641  0.55857709 -0.09126382
## 2025
```

```
dates_format <- read.csv('./Data/dates_formats3.csv', sep = ';')
head(dates_format)
```

```
##   Japanese_format US_format    CA_mix_format   SA_mix_format  NZ_format
## 1      20/01/2017 1/20/2017 January 20, 2017 20 January 2017 20/01/2017
## 2      21/01/2017 1/21/2017 January 21, 2017 21 January 2017 21/01/2017
## 3      22/01/2017 1/22/2017 January 22, 2017 22 January 2017 22/01/2017
## 4      23/01/2017 1/23/2017 January 23, 2017 23 January 2017 23/01/2017
## 5      24/01/2017 1/24/2017 January 24, 2017 24 January 2017 24/01/2017
## 6      25/01/2017 1/25/2017 January 25, 2017 25 January 2017 25/01/2017
```

```
attach(dates_format)
class(Japanese_format)
```

```
## [1] "character"
```

```
dates_format$Japanese_format <- as.Date(Japanese_format, format = "%d/%m/%Y")
dates_format
```

```
##    Japanese_format US_format     CA_mix_format    SA_mix_format  NZ_format
## 1       2017-01-20 1/20/2017  January 20, 2017  20 January 2017 20/01/2017
## 2       2017-01-21 1/21/2017  January 21, 2017  21 January 2017 21/01/2017
## 3       2017-01-22 1/22/2017  January 22, 2017  22 January 2017 22/01/2017
## 4       2017-01-23 1/23/2017  January 23, 2017  23 January 2017 23/01/2017
## 5       2017-01-24 1/24/2017  January 24, 2017  24 January 2017 24/01/2017
## 6       2017-01-25 1/25/2017  January 25, 2017  25 January 2017 25/01/2017
## 7       2017-01-26 1/26/2017  January 26, 2017  26 January 2017 26/01/2017
## 8       2017-01-27 1/27/2017  January 27, 2017  27 January 2017 27/01/2017
## 9       2017-01-28 1/28/2017  January 28, 2017  28 January 2017 28/01/2017
## 10      2017-01-29 1/29/2017  January 29, 2017  29 January 2017 29/01/2017
## 11      2017-01-30 1/30/2017  January 30, 2017  30 January 2017 30/01/2017
## 12      2017-01-31 1/31/2017  January 31, 2017  31 January 2017 31/01/2017
## 13      2017-02-01 2/01/2017  February 1, 2017 01 February 2017  1/02/2017
## 14      2017-02-02 2/02/2017  February 2, 2017 02 February 2017  2/02/2017
## 15      2017-02-03 2/03/2017  February 3, 2017 03 February 2017  3/02/2017
## 16      2017-02-04 2/04/2017  February 4, 2017 04 February 2017  4/02/2017
## 17      2017-02-05 2/05/2017  February 5, 2017 05 February 2017  5/02/2017
## 18      2017-02-06 2/06/2017  February 6, 2017 06 February 2017  6/02/2017
## 19      2017-02-07 2/07/2017  February 7, 2017 07 February 2017  7/02/2017
## 20      2017-02-08 2/08/2017  February 8, 2017 08 February 2017  8/02/2017
## 21      2017-02-09 2/09/2017  February 9, 2017 09 February 2017  9/02/2017
## 22      2017-02-10 2/10/2017 February 10, 2017 10 February 2017 10/02/2017
```

2. Time Series Decomposition

Time series can be decomposed into 4 components (TSCR) Trend, Seasonal, Cyclical, Random

- Trend : Increasing and decreasing trend in a data (e.g., linear, polynomial, exponential)
- Seasonal : seasonal variation that occurs periodically (e.g., hourly, weekly, monthly, quarterly)
- Cycle : sequence of repeatable event over long period of time, does not occur at equally spaced time intervals and length could change from cycle to cycle
- Irregular : Remainder between the series and structural component (TSC)

2.1 Additive Decomposition

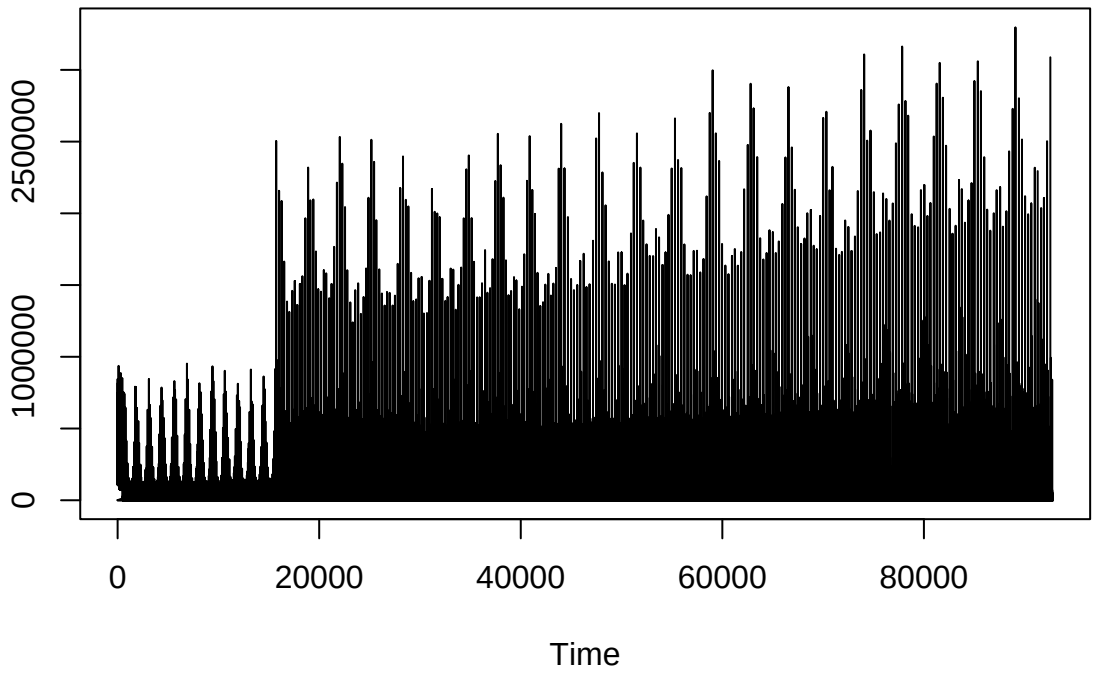
amplitude of the seasonal component roughly remain the same over time.

$Y_t = T_t + S_t + C_t + I_t$

```
library(USgas)
```

```
## Warning: package 'USgas' was built under R version 4.4.2
```

```
data(package = 'USgas')
data(usgas)
ts.plot(usgas)
```



2.2 Multiplicative Decomposition

Amplitude of the seasonal component increase over time.

$Y_t = T_t \times S_t \times C_t \times I_t$

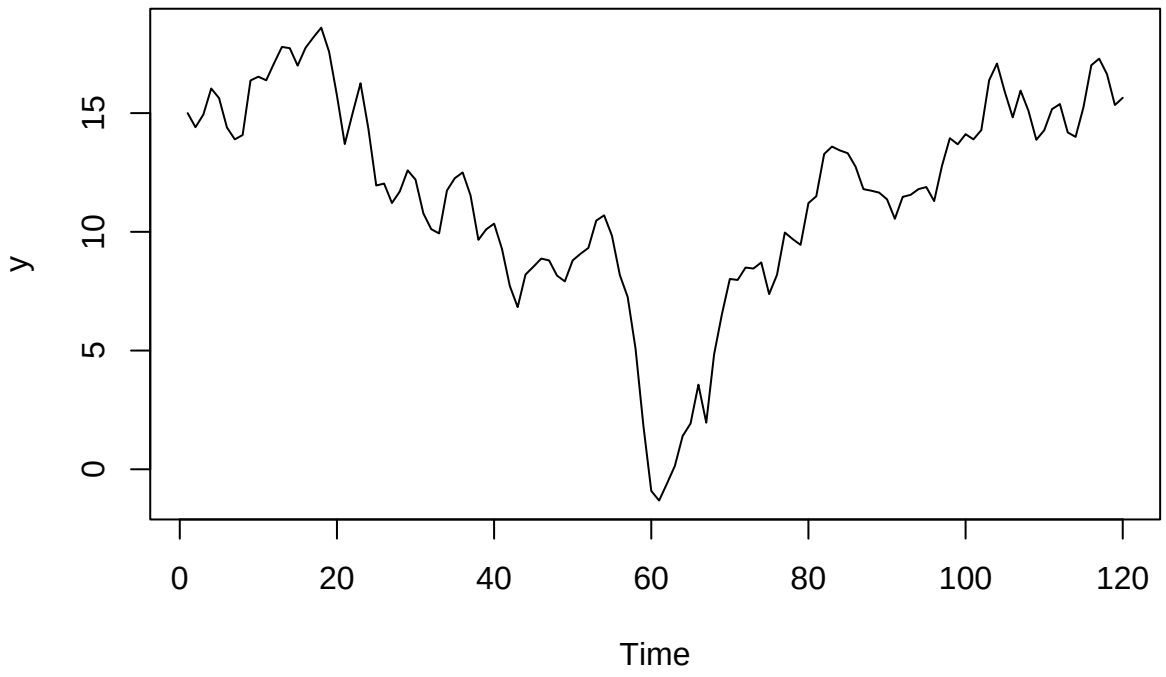
Basic ARIMA model

- AR : y depends on the past p values of observation
- MA : y depends on the past q residual values

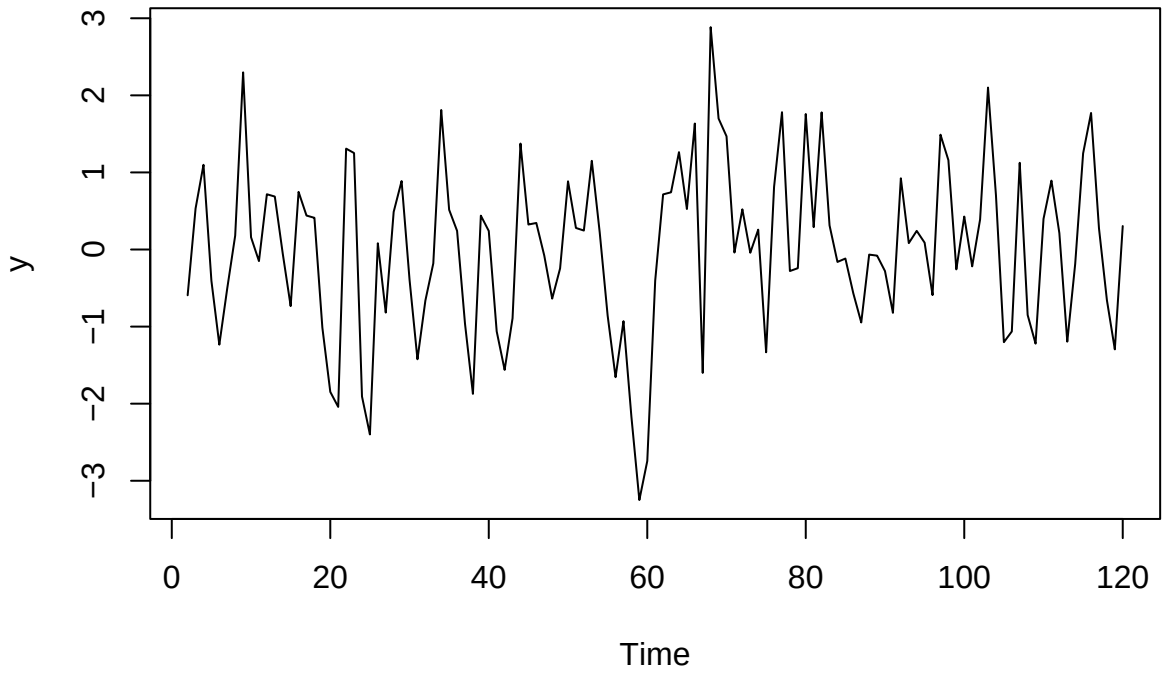
```r
towel <- read.csv('./Data/towel.csv')
head(towel)
```

```
##         y
## 1 15.0000
## 2 14.4064
## 3 14.9383
## 4 16.0374
## 5 15.6320
## 6 14.3975
```

```r
# convert into time series data
towel.ts = ts(towel)
plot.ts(towel.ts)
```

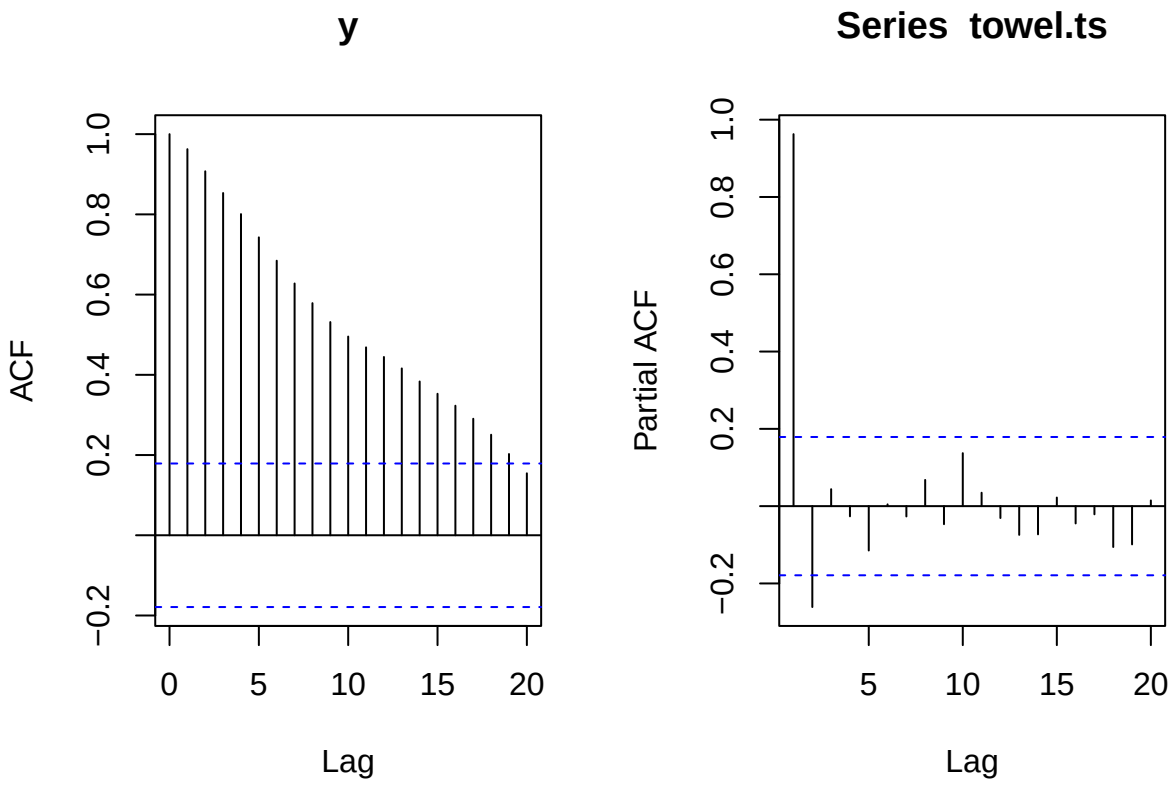



```r
# do differencing to achieve stationary
towel.dif = diff(towel.ts)
plot.ts(towel.dif)
```



Model	AC	PAC
Autoregressive of order p $y_t = \delta + \phi_1 y_{t-1} + \phi_2 y_{t-2} + \cdots + \phi_p y_{t-p} + \varepsilon_t$	Dies down	Cuts off after lag p
Moving Average of order q $y_t = \delta + \varepsilon_t - \theta_1 \varepsilon_{t-1} - \theta_2 \varepsilon_{t-2} - \cdots - \theta_q \varepsilon_{t-q}$	Cuts off after lag q	Dies down
Mixed Autoregressive-Moving Average of order (p,q) $y_t = \delta + \phi_1 y_{t-1} + \phi_2 y_{t-2} + \cdots + \phi_p y_{t-p} + \varepsilon_t - \theta_1 \varepsilon_{t-1} - \theta_2 \varepsilon_{t-2} - \cdots - \theta_q \varepsilon_{t-q}$	Dies down	Dies down

```
par(mfrow=c(1,2))
acf(towel.ts)
pacf(towel.ts)
```



Diagnostic

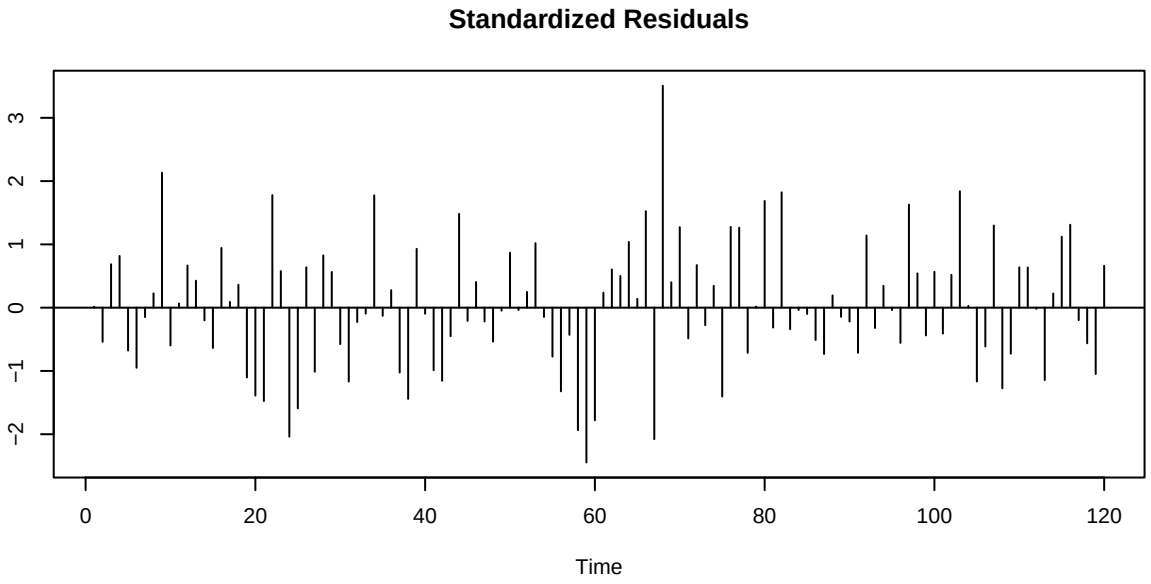
- Residuals should not be auto-correlated
- Residuals is distributed approximately normally
- The variance of the residuals is constant over time.

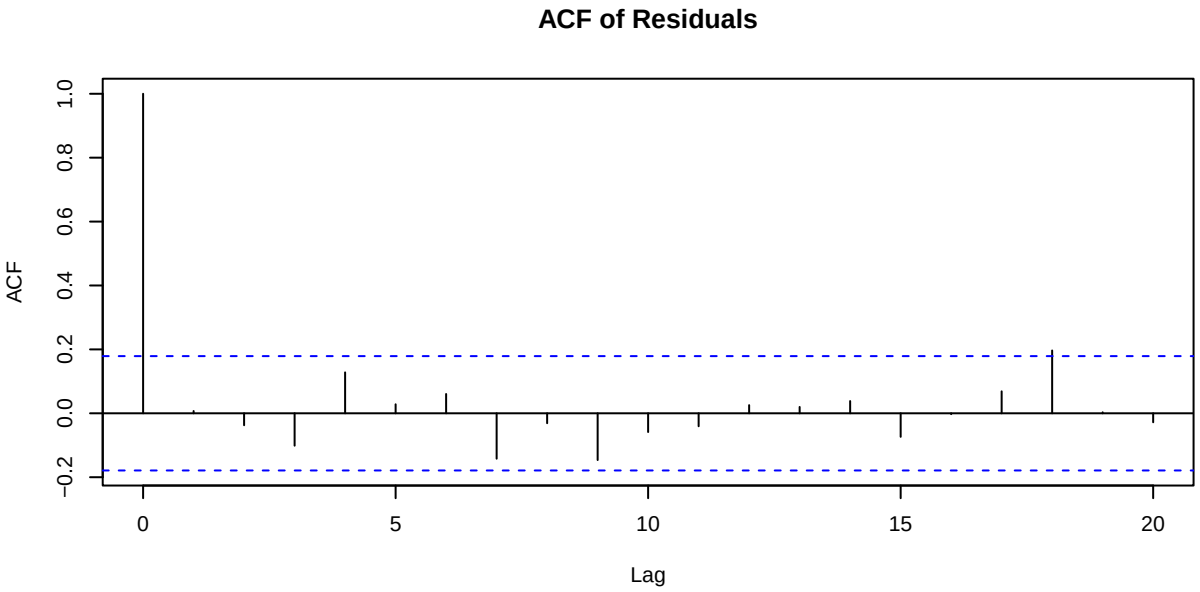
```
library(forecast)
```

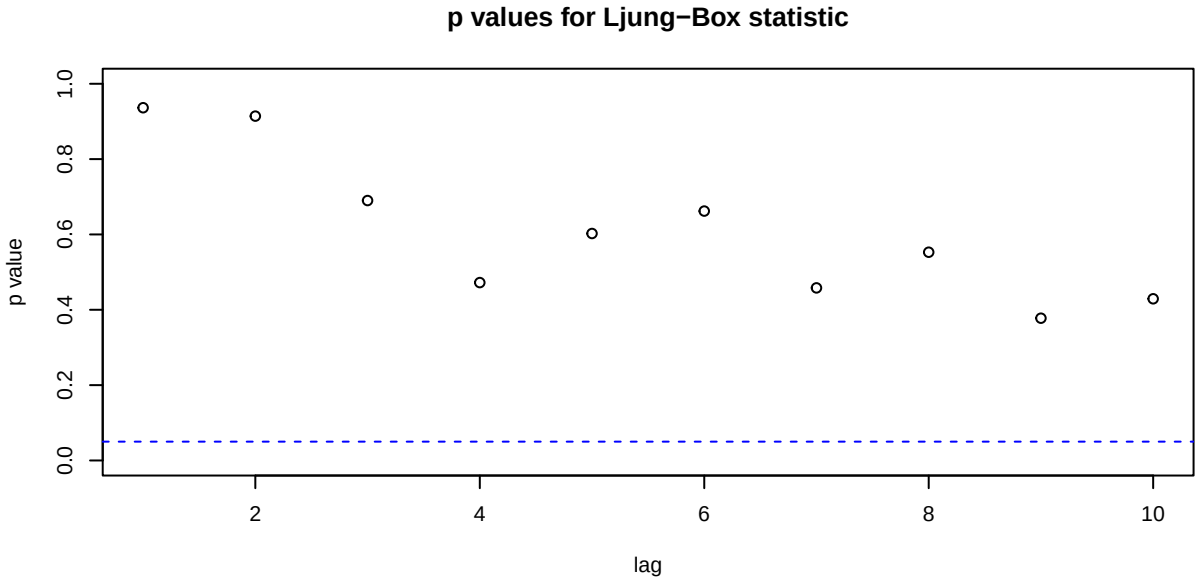
```
## Warning: package 'forecast' was built under R version 4.4.2
```

```
## Registered S3 method overwritten by 'quantmod':
##   method            from
##   as.zoo.data.frame zoo
```

```
tsdiag(auto.arima(towel.ts))
```





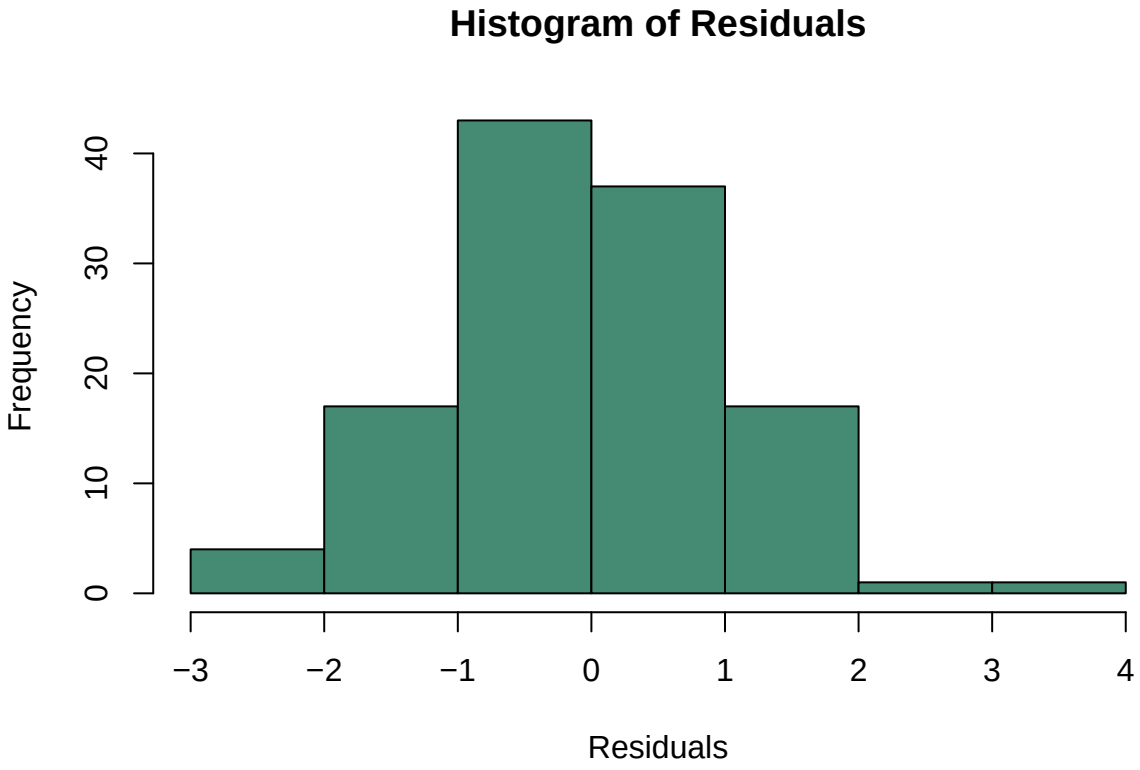


Interpretation :

- **Standardized residuals** : no pattern suggest homoscedasticity

- **ACF of residuals** : Residuals are not correlated.
- **p-value for Ljung-Box statistic** : p-value are all above significant line indicates this model

```
hist(residuals(auto.arima(towel.ts)), main = 'Histogram of Residuals',
     col = 'aquamarine4', xlab = 'Residuals')
```



2. Time Series Forecasting

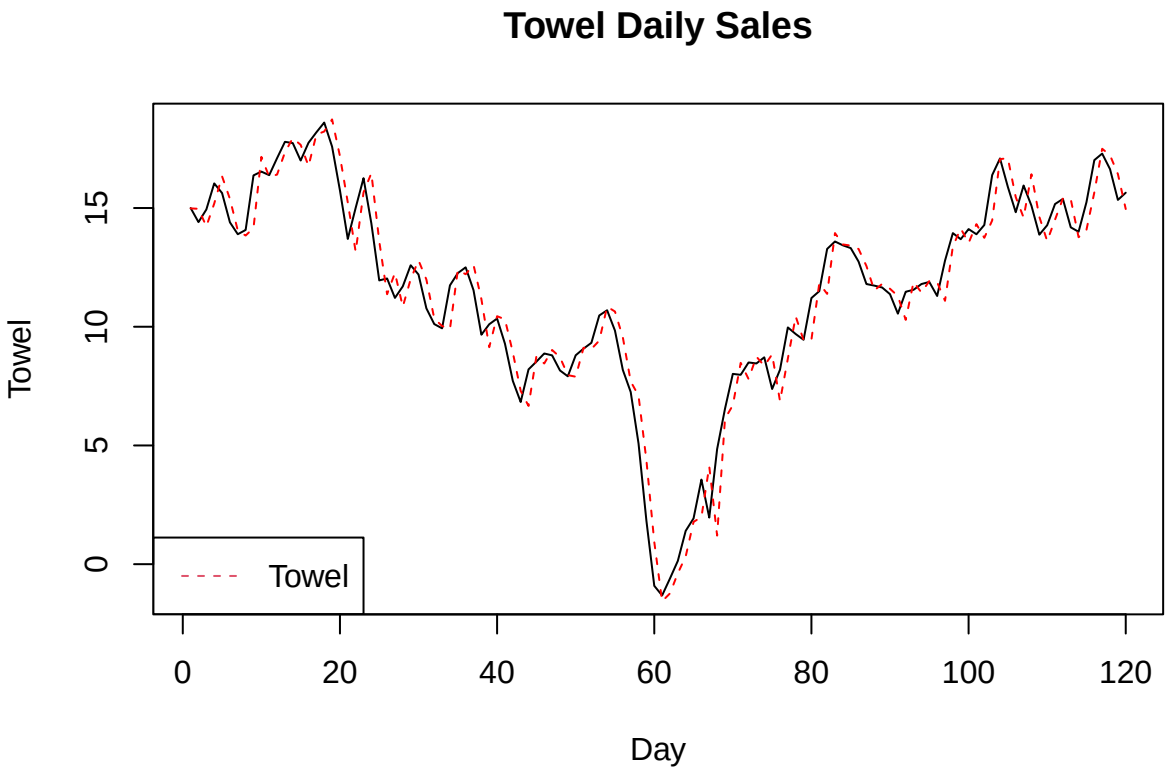
```
towel <- read.csv('./Data/towel.csv')
head(towel)
```

```
##         y
## 1 15.0000
## 2 14.4064
## 3 14.9383
## 4 16.0374
## 5 15.6320
## 6 14.3975
```

```
head(ts(towel))
```

```
## Time Series:
## Start = 1
## End = 6
## Frequency = 1
##            y
## [1,] 15.0000
## [2,] 14.4064
## [3,] 14.9383
## [4,] 16.0374
## [5,] 15.6320
## [6,] 14.3975
```

```
library(forecast)
ts.plot(ts(towel), main = 'Towel Daily Sales', xlab = 'Day', ylab = 'Towel')
lines(fitted(auto.arima(ts(towel))), col = 'red', lty = 2)
legend('bottomleft', 'Towel', col = 2, lty = 2)
```



We can see that the data is not stationary (pegun). How to determine whether a data is stationary or not?

A stationary data satisfy these conditions:

1. Mean is constant over time
2. Variance is constant over time

Then, what should we do if the data is not stationary, we can do differencing (pembezaan) on the data manually or can do it automatically

```
auto.arima(ts(towel))
```

```
## Series: ts(towel)
## ARIMA(0,1,1)
##
## Coefficients:
##          ma1
##       0.3518
## s.e.  0.0800
##
## sigma^2 = 1.08:  log likelihood = -172.99
## AIC=349.98   AICc=350.08   BIC=355.53
```

after we find the ARIMA model,

```
model <- arima(ts(towel), order = c(0,1,1))
summary(model)
```

```
##
## Call:
## arima(x = ts(towel), order = c(0, 1, 1))
##
## Coefficients:
##          ma1
##       0.3518
## s.e.  0.0800
##
## sigma^2 estimated as 1.071:  log likelihood = -172.99,  aic = 349.98
##
## Training set error measures:
##                       ME     RMSE       MAE      MPE    MAPE      MASE
## Training set 0.005711291 1.030456 0.8053392 3.003594 15.5468 0.9337157
##                     ACF1
## Training set 0.007198121
```

```
f1 <- forecast(model)
f1
```

```
##     Point Forecast    Lo 80    Hi 80     Lo 95    Hi 95
## 121       15.88729 14.56117 17.21341 13.859170 17.91542
## 122       15.88729 13.65741 18.11717 12.476983 19.29760
## 123       15.88729 13.02615 18.74844 11.511549 20.26304
## 124       15.88729 12.51091 19.26367 10.723567 21.05102
## 125       15.88729 12.06450 19.71008 10.040841 21.73375
## 126       15.88729 11.66503 20.10956  9.429900 22.34469
## 127       15.88729 11.30022 20.47437  8.871963 22.90262
## 128       15.88729 10.96235 20.81224  8.355243 23.41934
## 129       15.88729 10.64622 21.12837  7.871764 23.90282
## 130       15.88729 10.34810 21.42648  7.415833 24.35875
```

```
f2 <- forecast(auto.arima(ts(towel)))
f2
```

```
##     Point Forecast    Lo 80    Hi 80     Lo 95    Hi 95
## 121       15.88729 14.55557 17.21902 13.850593 17.92399
## 122       15.88729 13.64798 18.12661 12.462560 19.31203
## 123       15.88729 13.01405 18.76054 11.493042 20.28154
## 124       15.88729 12.49663 19.27795 10.701728 21.07286
## 125       15.88729 12.04834 19.72625 10.016115 21.75847
## 126       15.88729 11.64717 20.12741  9.402590 22.37200
## 127       15.88729 11.28082 20.49377  8.842294 22.93229
## 128       15.88729 10.94152 20.83307  8.323388 23.45120
## 129       15.88729 10.62405 21.15053  7.837864 23.93672
## 130       15.88729 10.32468 21.44991  7.380005 24.39458
```

```
predict(auto.arima(ts(towel)), n.ahead = 10)
```

```
## $pred
## Time Series:
## Start = 121
## End = 130
## Frequency = 1
##  [1] 15.88729 15.88729 15.88729 15.88729 15.88729 15.88729 15.88729 15.88729
##  [9] 15.88729 15.88729
##
## $se
## Time Series:
## Start = 121
## End = 130
## Frequency = 1
```

```
##  [1] 1.039152 1.747345 2.242006 2.645745 2.995554 3.308583 3.594454 3.859206
##  [9] 4.106927 4.340533
```

```
str(f1)
```

```
## List of 10
##  $ method   : chr "ARIMA(0,1,1)"
##  $ model    :List of 15
##   ..$ coef     : Named num 0.352
##   .. ..- attr(*, "names")= chr "ma1"
##   ..$ sigma2   : num 1.07
##   ..$ var.coef : num [1, 1] 0.00641
##   .. ..- attr(*, "dimnames")=List of 2
##   .. .. ..$ : chr "ma1"
##   .. .. ..$ : chr "ma1"
##   ..$ mask     : logi TRUE
##   ..$ loglik   : num -173
##   ..$ aic      : num 350
##   ..$ arma     : int [1:7] 0 1 0 0 1 1 0
##   ..$ residuals: Time-Series [1:120] from 1 to 120: 0.015 -0.56 0.713 0.849 -0.704 ...
##   ..$ call     : language arima(x = ts(towel), order = c(0, 1, 1))
##   ..$ series   : chr "ts(towel)"
##   ..$ code     : int 0
##   ..$ n.cond   : int 0
##   ..$ nobs     : int 119
##   ..$ model    :List of 10
##   .. ..$ phi  : num(0)
##   .. ..$ theta: num 0.352
##   .. ..$ Delta: num 1
##   .. ..$ Z    : num [1:3] 1 0 1
##   .. ..$ a    : num [1:3] 0.304 0.242 15.341
##   .. ..$ P    : num [1:3, 1:3] 0.00 0.00 2.17e-21 0.00 0.00 ...
##   .. ..$ T    : num [1:3, 1:3] 0 0 1 1 0 0 0 0 1
##   .. ..$ V    : num [1:3, 1:3] 1 0.352 0 0.352 0.124 ...
##   .. ..$ h    : num 0
##   .. ..$ Pn   : num [1:3, 1:3] 1.00 3.52e-01 -1.18e-21 3.52e-01 1.24e-01 ...
##   ..$ x        : Time-Series [1:120, 1] from 1 to 120: 15 14.4 14.9 16 15.6 ...
##   .. ..- attr(*, "dimnames")=List of 2
##   .. .. ..$ : NULL
##   .. .. ..$ : chr "y"
##   ..- attr(*, "class")= chr "Arima"
##  $ level    : num [1:2] 80 95
##  $ mean     : Time-Series [1:10] from 121 to 130: 15.9 15.9 15.9 15.9 15.9 ...
##  $ lower    : Time-Series [1:10, 1:2] from 121 to 130: 14.6 13.7 13 12.5 12.1 ...
##   ..- attr(*, "dimnames")=List of 2
##   .. ..$ : NULL
##   .. ..$ : chr [1:2] "80%" "95%"
##  $ upper    : Time-Series [1:10, 1:2] from 121 to 130: 17.2 18.1 18.7 19.3 19.7 ...
##   ..- attr(*, "dimnames")=List of 2
##   .. ..$ : NULL
##   .. ..$ : chr [1:2] "80%" "95%"
##  $ x        : Time-Series [1:120, 1] from 1 to 120: 15 14.4 14.9 16 15.6 ...
##   ..- attr(*, "dimnames")=List of 2
##   .. ..$ : NULL
##   .. ..$ : chr "y"
##  $ series   : chr "ts(towel)"
##  $ fitted   : Time-Series [1:120, 1] from 1 to 120: 15 15 14.2 15.2 16.3 ...
##   ..- attr(*, "dimnames")=List of 2
##   .. ..$ : NULL
##   .. ..$ : chr "x"
##  $ residuals: Time-Series [1:120] from 1 to 120: 0.015 -0.56 0.713 0.849 -0.704 ...
##  - attr(*, "class")= chr "forecast"
```

```
f1$lower[,1]
```

```
## Time Series:
## Start = 121
## End = 130
## Frequency = 1
##  [1] 14.56117 13.65741 13.02615 12.51091 12.06450 11.66503 11.30022 10.96235
##  [9] 10.64622 10.34810
```

```
identical(f1, f2)
```

```
## [1] FALSE
```

3. Time Series Clustering

```
load('./Data/sample2.RData')
str(sample2)
```

```
## 'data.frame':    60 obs. of  60 variables:
##  $ V1 : num  28.2 29.2 27.2 24.1 24 ...
##  $ V2 : num  30.8 31.5 25.8 33 32.9 ...
##  $ V3 : num  33.9 33.2 28.7 35.5 33.9 ...
##  $ V4 : num  26.7 35.6 31.4 28.6 33.3 ...
##  $ V5 : num  27.5 31.6 31.6 28.8 30.3 ...
##  $ V6 : num  28.1 35.1 30.2 32.5 28.8 ...
##  $ V7 : num  32.5 28.6 31.6 30 25.6 ...
##  $ V8 : num  33.7 34.3 32.2 24.3 24.3 ...
##  $ V9 : num  26 33.1 30.9 24.4 24.2 ...
##  $ V10: num  32.7 35.7 30.7 34.1 33.2 ...
##  $ V11: num  34.3 29.7 34.8 30.4 34 ...
##  $ V12: num  30.3 28.2 31.9 33.7 33.8 ...
##  $ V13: num  29.8 30.5 29.4 29.9 28.3 ...
##  $ V14: num  33 24.8 27.9 33.2 31.1 ...
##  $ V15: num  35.6 26.4 27.1 33.2 34.5 ...
##  $ V16: num  27.7 28 27.3 29.4 24.5 ...
##  $ V17: num  32.9 33.6 30.9 30 24.2 ...
##  $ V18: num  28.4 34 31 25.3 30.3 ...
##  $ V19: num  28.5 33.8 31.8 27.8 31.8 ...
##  $ V20: num  25.6 24.5 29.1 24.6 24.1 ...
##  $ V21: num  30.6 26.1 34.1 34.9 25.3 ...
##  $ V22: num  31.9 32.9 31.9 27.4 30.6 ...
##  $ V23: num  29.9 27.3 31.2 31 33.5 ...
##  $ V24: num  28.3 35.6 29.9 25 31.7 ...
##  $ V25: num  32 31.4 31.6 34.9 35.9 ...
##  $ V26: num  29.8 26.9 27.8 29 33.1 ...
##  $ V27: num  35.3 24.2 32 30.1 35.1 ...
##  $ V28: num  34.2 25.9 32.6 25.3 33.5 ...
##  $ V29: num  32.3 30.7 34.8 35.3 28.4 ...
##  $ V30: num  34.4 32.7 24.7 27.4 33.5 ...
##  $ V31: num  32 24.3 32.6 24 30.4 ...
##  $ V32: num  28.6 29.6 36 28 28 ...
##  $ V33: num  24.4 27.6 35.3 26.3 25.9 ...
##  $ V34: num  33.5 26.7 30.4 29.5 32.1 ...
##  $ V35: num  30.4 24.4 32.6 29.7 30.6 ...
##  $ V36: num  28.4 34.2 26.3 30.1 35.5 ...
##  $ V37: num  35.2 27.6 31.3 24.3 27.1 ...
##  $ V38: num  33.5 24.3 29.6 31 28 ...
##  $ V39: num  32.7 32.6 25.3 27.7 34.6 ...
##  $ V40: num  28.1 25.1 29.1 25.7 27.3 ...
##  $ V41: num  35.2 35.3 29.5 28.3 28.4 ...
```

```
##  $ V42: num  25.1 36 33.7 34.6 31.9 ...
##  $ V43: num  29.6 34.3 31.6 28.1 30 ...
##  $ V44: num  29.4 26.9 29.6 32.6 26.2 ...
##  $ V45: num  33.5 31.7 33.9 28.1 35.5 ...
##  $ V46: num  30.8 35.5 27.5 33.8 26.5 ...
##  $ V47: num  27.5 28.3 30.2 24.6 26.4 ...
##  $ V48: num  26.2 35.6 32.2 32.5 25.4 ...
##  $ V49: num  25.8 31.8 35.4 26.3 32.2 ...
##  $ V50: num  27.2 33.8 29.3 25.2 31.3 ...
##  $ V51: num  30.1 35.7 33.6 31 33.8 ...
##  $ V52: num  32.1 25.5 31.9 26.4 25.5 ...
##  $ V53: num  35.4 30.6 29.3 32.3 27.1 ...
##  $ V54: num  34.6 33.3 24.3 35.3 31.5 ...
##  $ V55: num  24.1 33 24 27.2 34.8 ...
##  $ V56: num  34.7 24 34.7 34.7 28.8 ...
##  $ V57: num  35.3 32.8 25.8 25.7 24.4 ...
##  $ V58: num  34.1 29.2 34.9 32 35.4 ...
##  $ V59: num  24.8 35.5 32.2 33.9 31.7 ...
##  $ V60: num  33.7 25.9 32.5 26 26.2 ...
```

```
library(dtw)
dist(sample2, method = 'DTW')
```

```
##            16        10        58        15        82        91        11
## 10   175.1280
## 58   144.1657  171.9889
## 15   166.9458  163.0294  196.0601
## 82   170.7334  165.2784  192.9108  161.3009
## 91   163.6098  172.9859  166.7570  184.2107  168.7043
## 11   195.9865  182.3403  204.9765  190.9235  187.0962  200.3000
## 9    183.9797  174.1057  190.2381  174.8510  187.2452  193.2259  174.6517
## 57   182.9158  176.2096  179.0649  160.2957  165.0189  173.8225  172.1541
## 49   163.1556  182.0432  161.1173  171.6772  187.3219  177.0821  178.5544
## 116  329.2900  331.0366  347.1432  345.3147  351.3869  340.2702  375.7339
## 110  412.4996  389.3421  431.4444  392.5875  411.7251  406.7473  386.8013
## 158  306.7922  338.4695  319.0572  316.3249  318.0288  315.0440  306.1883
## 115  314.6060  301.5108  309.3024  318.5051  330.4084  297.9523  323.8169
## 182  391.6906  360.7782  379.5559  380.0575  391.5457  386.0444  358.2902
## 191  457.1948  422.9261  455.5199  447.3367  436.1005  432.1660  452.7524
## 111  457.5511  482.9348  465.5950  491.5149  508.8061  462.9060  468.8489
## 109  375.7010  378.9904  398.2781  396.3763  374.5768  379.9558  388.9362
## 157  463.2064  480.4719  464.1849  509.7655  516.7934  474.7728  509.2513
## 149  446.7099  437.0666  450.0722  454.6354  444.7990  455.3046  416.1305
## 216  826.4922  800.3383  804.5198  878.7758  831.0711  757.4787  884.9138
## 210  740.6852  719.9976  744.3946  788.5271  744.6802  688.3748  799.1393
## 258  511.5507  500.6385  488.5145  548.2394  514.5929  469.2607  584.2304
## 215  563.7351  551.2358  554.8192  607.5049  585.5175  530.9445  632.6973
## 282  418.3971  422.6791  432.1538  462.0719  446.1832  399.4993  495.5733
## 291  479.8153  486.2968  463.1286  535.5405  501.3543  442.9482  551.7522
## 211  394.2444  406.8931  392.6001  442.4436  426.2136  374.5052  464.4990
## 209  737.2810  715.3253  726.4019  787.6761  757.0085  680.9282  820.6890
## 257  608.3304  590.2800  610.3613  655.7898  620.8541  558.5648  672.2675
## 249  672.1137  658.3494  642.9390  720.7345  684.7243  612.2686  758.1122
## 316  782.3056  815.9420  813.9956  818.4009  806.9538  848.5733  907.5346
## 310  674.1048  707.6508  689.2203  702.2251  695.7891  728.7550  775.4822
## 358  759.5318  784.7909  797.9506  781.0134  782.3751  821.6977  865.3701
## 315  689.7036  705.7095  718.9107  709.2578  696.3422  750.6292  778.4101
## 382  647.0202  686.7918  659.5400  681.4913  671.3781  710.2219  756.8518
## 391  756.6014  798.7839  795.8240  790.7428  789.2344  815.0340  881.6153
## 311  794.9235  819.5027  822.4442  822.9499  817.2233  862.2246  904.9188
## 309  431.9679  453.1353  454.3822  459.3160  423.5933  471.7541  476.5173
## 357  296.8420  312.9019  306.5631  319.9087  304.2201  335.3904  317.8638
## 349  379.9298  398.0071  372.8486  426.9845  397.8384  431.0043  400.7940
```

```
## 416  427.3556  424.1760  425.1307  457.8307  422.6760  394.1854  477.5533
## 410  416.7125  433.9305  394.3301  473.7980  445.8931  393.1413  492.0611
## 458  573.4030  585.8512  551.8523  627.9127  582.5162  548.9773  628.5763
## 415  459.4040  476.9384  461.7285  512.7724  486.3578  436.7941  531.4936
## 482  473.2471  473.0897  471.3512  514.5563  471.8153  444.8954  523.3485
## 491  274.9795  279.9997  267.9129  307.2508  297.0211  288.5079  316.6242
## 411  286.7039  279.8211  289.0663  303.0023  289.4373  280.2153  337.0956
## 409  514.3473  514.0479  494.7017  551.1865  517.6003  481.6217  563.1958
## 457  627.5547  604.3573  618.0067  663.9866  649.1852  589.5756  688.5234
## 449  603.8714  608.4002  588.0258  647.4232  611.7859  564.4548  655.9725
## 516  490.3972  498.2236  477.1504  525.3784  497.6744  530.9871  562.7056
## 510  298.1177  327.1161  299.6660  362.4249  320.4068  328.5151  340.9911
## 558  244.3351  247.3566  246.0886  244.9287  220.8859  263.4180  230.6287
## 515  458.4887  476.3788  497.8260  494.8522  484.7094  518.5549  551.7643
## 582  558.4922  585.4574  568.0021  631.9905  594.1992  620.1393  643.4169
## 591  391.3356  411.6931  432.5499  416.2209  405.6877  444.7050  486.9401
## 511  393.2345  384.5817  387.8119  436.5029  400.4979  429.6109  441.2595
## 509  416.6172  426.6450  461.7612  459.5775  434.6470  474.3889  467.1983
## 557  331.2201  329.0783  307.0269  377.7614  349.9872  361.6908  366.7179
## 549  587.0573  608.3581  618.6086  615.0500  603.0659  626.7392  670.9693
##             9        57        49       116       110       158       115
## 10
## 58
## 15
## 82
## 91
## 11
## 9
## 57   164.4125
## 49   153.0165  184.3468
## 116  344.8343  330.3620  345.6073
## 110  403.3874  416.9524  406.8755  295.5500
## 158  304.7006  320.7581  288.2042  336.7648  259.9603
## 115  311.4715  318.6337  306.1945  246.8503  332.2817  269.1133
## 182  385.7393  360.4200  380.9130  255.8917  231.3441  285.5706  278.2683
## 191  465.4668  447.7683  456.6107  289.3515  343.3710  339.6877  367.1080
## 111  456.7924  473.6344  456.5273  308.4226  258.1221  285.0677  311.8032
## 109  379.6993  387.0614  388.2885  358.1955  321.7303  313.6220  326.2104
## 157  488.1908  524.2834  477.3408  353.2030  289.1832  316.8130  312.5230
## 149  472.4503  454.4991  464.5975  334.0386  336.8638  314.4886  388.1866
## 216  899.9221  939.6868  737.8263  875.0836  866.1553  621.1048  733.7122
## 210  793.5789  846.6302  649.5476  784.8242  790.2005  566.8792  620.9641
## 258  582.9039  587.1045  452.8861  584.1407  590.6502  409.7886  478.9324
## 215  617.6892  658.4277  489.7379  704.2768  705.4041  488.7204  554.9464
## 282  486.5476  507.3609  370.0488  560.9853  582.4969  360.4161  400.0814
## 291  542.3131  564.3754  435.2316  590.8589  628.8956  443.8754  461.8727
## 211  451.0164  469.2712  354.7309  543.9814  579.7249  385.8108  424.3972
## 209  815.4536  855.0778  648.5208  807.0390  826.8892  587.6550  665.1433
## 257  671.0913  709.3697  542.0269  659.7261  690.0414  483.7147  538.8532
## 249  765.9814  783.2014  594.5434  763.3026  772.8675  516.0699  618.6798
## 316  881.4033  826.0864  815.1398  588.4384  791.0603  976.8035  937.3255
## 310  758.7420  693.1954  696.8148  540.0836  737.2655  870.0883  841.4203
## 358  860.3303  800.9359  783.1251  566.9694  794.0769  941.6001  940.3617
## 315  749.2224  709.0763  690.6125  496.3731  678.4012  817.0195  819.0900
## 382  739.7234  682.0211  671.7484  527.3991  657.4242  800.9801  821.8595
## 391  872.0570  796.9382  789.7751  587.7537  802.3301  983.8889  942.7474
## 311  892.3242  837.8666  829.8585  527.9664  769.3356  927.3580  946.3951
## 309  471.4559  433.0463  443.1499  420.8000  521.6431  598.7788  569.7374
## 357  324.0263  298.5065  300.3700  384.7282  471.4751  481.2695  463.0333
## 349  402.8837  387.8868  395.6313  364.6725  438.3759  473.6616  500.2464
## 416  456.8217  474.8644  384.1068  473.4160  482.2014  339.6419  417.8467
## 410  487.0535  500.9988  397.5624  618.8456  658.1216  411.3575  464.0841
## 458  639.9155  657.0336  533.4181  631.9233  623.2834  421.7111  535.4592
## 415  517.6733  549.4892  421.1514  550.3138  557.8984  403.1910  443.9433
```

```
## 482  541.7588  560.3967  435.4080  546.2614  550.3333  356.3866  462.2375
## 491  303.6780  297.5684  284.9972  434.1536  454.6514  314.9782  367.8393
## 411  309.0959  332.7755  263.3596  415.1493  446.1599  333.1699  326.0159
## 409  538.1757  569.7415  451.8028  527.6136  541.1377  376.7483  454.2626
## 457  677.6342  723.2457  563.0500  696.0687  672.6708  430.4637  560.9914
## 449  660.3213  697.8517  552.5136  586.8539  604.7479  391.8755  528.1111
## 516  546.1916  501.4544  517.9954  350.1469  503.2757  601.6501  580.0385
## 510  335.8130  310.1975  339.6613  362.2085  459.8880  435.2844  427.1881
## 558  224.2427  203.8213  242.6285  317.0965  426.2371  359.6406  367.1334
## 515  512.2972  466.8071  489.7389  370.9560  458.4230  537.5934  562.3735
## 582  629.0548  581.4827  609.6208  419.9534  534.3978  610.6819  598.2454
## 591  453.6550  424.0183  426.2505  396.3721  484.5519  566.2147  576.3478
## 511  424.4846  397.5772  431.2305  370.4580  454.1659  488.5243  481.1578
## 509  472.6665  433.1884  458.1481  353.4361  486.5024  551.8799  538.3884
## 557  353.5782  340.1391  374.0903  340.6480  399.8583  410.9724  444.8728
## 549  653.8127  617.0528  621.5486  405.7764  593.2543  701.7157  718.2135
##           182       191       111       109       157       149       216
## 10
## 58
## 15
## 82
## 91
## 11
## 9
## 57
## 49
## 116
## 110
## 158
## 115
## 182
## 191  317.0607
## 111  298.6713  358.5672
## 109  309.0362  288.3550  329.0478
## 157  328.9365  393.1221  269.5958  353.7915
## 149  325.9122  274.3806  367.1752  343.7351  389.4240
## 216  805.1517  858.6777  637.6681  836.5676  703.3033  757.1477
## 210  766.3368  806.0262  586.8305  745.9485  667.7633  707.0131  176.7453
## 258  587.3715  601.0278  545.1220  541.0853  550.0343  594.5751  238.0743
## 215  686.2869  735.4474  585.2514  646.3527  595.4377  711.3758  193.3705
## 282  587.5652  603.4359  526.4884  490.3294  514.4958  587.0745  267.0942
## 291  610.4768  660.6785  546.1680  576.3543  579.8801  630.4615  203.9899
## 211  547.3040  606.6419  521.6474  530.0703  543.0441  578.3284  317.4725
## 209  774.8533  815.6385  590.6338  760.7838  672.9532  728.0638  186.3797
## 257  642.7841  685.8969  525.6841  645.0844  592.5565  627.4209  187.4107
## 249  734.6865  770.1092  552.4348  726.2985  625.0091  664.9010  187.6744
## 316  701.2434  710.9590  864.6781  904.9058  841.1203  665.8931 2867.1367
## 310  649.3816  640.1871  823.4902  797.0925  811.9173  590.4126 2542.4639
## 358  668.7750  681.9107  881.6839  881.3672  829.6033  646.3389 2768.7468
## 315  578.4629  611.9814  755.3418  759.4720  728.0598  591.5309 2531.3495
## 382  615.3425  599.7273  754.5138  742.2208  735.9651  596.3133 2477.9494
## 391  726.3452  699.6076  875.3323  903.3866  826.5083  648.4218 2820.4087
## 311  679.2866  642.9511  841.7553  859.9165  780.5019  610.3545 2824.9890
## 309  463.3757  524.8751  600.9928  592.3491  639.8039  483.0316 1944.4676
## 357  460.7856  481.1587  573.2666  483.5174  603.3828  456.7659 1563.6178
## 349  414.5594  485.2992  542.1793  508.2119  539.3892  468.3561 1630.6319
## 416  484.8637  535.9122  522.4786  483.3615  508.2753  565.0660  367.7129
## 410  606.1491  661.6488  502.6564  564.3592  536.3398  581.6965  251.2541
## 458  570.5515  630.9203  557.2632  547.3573  563.1127  559.4955  302.5337
## 415  550.6911  629.4016  560.0213  522.6191  556.1025  640.5049  297.1813
## 482  545.5687  572.3504  541.3730  531.5401  519.5424  558.7746  360.6703
## 491  464.6655  516.0576  518.4839  441.5788  521.5269  496.9733  565.3128
## 411  438.1433  478.5134  505.8696  415.1446  503.7343  495.9307  452.2819
## 409  541.6940  590.0964  565.1622  533.1911  523.5025  599.1315  359.5486
```

```
## 457  624.7726  681.0840  501.0955  614.2271  561.9972  588.3617  285.5049
## 449  585.9369  624.4602  542.0483  572.8904  563.3500  592.9815  292.5477
## 516  449.6273  467.1835  554.3017  538.5000  555.3603  448.9096 1938.2141
## 510  430.8964  476.4940  512.4479  475.1514  530.7926  460.0181 1445.9496
## 558  397.0740  433.6814  487.3893  409.3047  518.4816  452.0862 1281.4766
## 515  413.1531  487.9575  527.9795  533.7974  593.5587  435.0354 1982.9833
## 582  508.1844  549.3079  603.2473  586.0947  620.4711  495.2484 2026.8166
## 591  451.2492  486.5355  567.1190  530.4514  599.0338  439.1375 1770.3262
## 511  427.4373  471.3820  519.3928  488.2188  560.0169  454.7943 1716.5551
## 509  439.0724  458.8486  558.7986  543.1909  549.8173  436.6915 1821.2556
## 557  420.6317  457.6400  494.2704  461.4041  536.4781  468.1237 1511.1746
## 549  558.2255  480.5482  659.5020  656.0190  591.5777  488.0520 2060.6935
##           210       258       215       282       291       211       209
## 10
## 58
## 15
## 82
## 91
## 11
## 9
## 57
## 49
## 116
## 110
## 158
## 115
## 182
## 191
## 111
## 109
## 157
## 149
## 216
## 210
## 258  233.4554
## 215  192.2041  191.6450
## 282  263.7349  165.5706  212.2624
## 291  196.5622  181.4513  183.6643  198.9183
## 211  280.7295  184.2833  210.6769  183.4964  185.2353
## 209  172.7391  196.5368  192.2933  251.2537  194.5812  272.9075
## 257  191.1697  196.4908  189.0324  182.5498  188.3735  210.8263  167.8796
## 249  203.0775  211.0436  195.9927  217.5148  205.3168  217.4082  182.3841
## 316 2662.1948 2095.6749 2230.3193 1909.5114 2011.4366 1780.1801 2748.0673
## 310 2469.0025 1957.4453 2083.2299 1759.0281 1881.6865 1677.6902 2488.1384
## 358 2593.2628 2025.1200 2180.1026 1864.3254 1954.6782 1729.9162 2653.0465
## 315 2434.4271 1984.9806 2083.7607 1794.4110 1870.9583 1676.3839 2489.4399
## 382 2405.8013 1917.3027 2041.5942 1715.0221 1854.5633 1652.1416 2450.7030
## 391 2646.6788 2128.3875 2289.7396 1945.8929 2070.8337 1847.1186 2715.6278
## 311 2670.9274 2111.5726 2251.4975 1920.0435 2052.2794 1817.8091 2713.5613
## 309 1874.2111 1568.8040 1681.8678 1403.3633 1524.1811 1364.7753 1909.7532
## 357 1487.7610 1209.7465 1307.7841 1094.5116 1212.3541 1085.1260 1503.4783
## 349 1602.1631 1297.5790 1399.3466 1210.7219 1353.7889 1227.6786 1617.8542
## 416  343.4806  221.6644  285.6033  214.0072  247.5515  206.0767  340.0201
## 410  274.5103  246.6985  250.7805  245.6002  239.6597  246.6074  249.1719
## 458  319.4254  277.0722  299.5206  275.0139  276.8185  281.5167  304.2282
## 415  296.0241  221.1846  237.8159  202.7355  226.2059  227.9480  261.0948
## 482  345.7744  241.9995  291.1835  231.4226  271.4426  250.4224  332.8638
## 491  482.6849  305.3460  369.3351  261.4331  320.2692  252.7834  499.5432
## 411  411.6199  253.7007  312.6596  233.0855  269.8167  224.6179  403.1346
## 409  340.5504  242.5912  254.4872  225.1278  258.6181  245.1796  325.4817
## 457  292.6711  291.7202  263.1180  289.2843  266.3026  276.2195  281.0331
## 449  304.1345  278.0441  280.7931  256.3285  261.5138  280.7864  297.2433
## 516 1810.1794 1378.6157 1478.4398 1232.1371 1321.1018 1162.2621 1843.0342
## 510 1385.5363 1110.1571 1210.3616 1005.5114 1084.3360  958.7676 1399.7819
```

```
## 558 1194.1854  957.8059 1030.6501  838.5865  934.9923  816.3089 1213.3024
## 515 1806.5010 1391.0757 1497.9142 1233.0408 1317.4276 1155.5595 1865.2255
## 582 1957.0384 1633.4936 1715.1654 1434.6928 1528.7747 1378.8262 1989.8740
## 591 1607.8478 1198.7075 1337.7079 1118.4929 1197.5484 1009.6076 1655.6850
## 511 1627.6880 1298.6707 1368.2469 1133.7947 1210.4423 1062.3666 1653.5981
## 509 1639.4492 1269.7960 1371.4627 1130.5483 1214.5430 1040.9591 1714.8136
## 557 1479.7426 1146.0047 1270.1629 1062.1124 1226.5762 1098.4799 1481.9519
## 549 1888.0496 1451.8259 1607.9668 1353.6647 1441.3101 1239.1352 1949.4793
##           257       249       316       310       358       315       382
## 10
## 58
## 15
## 82
## 91
## 11
## 9
## 57
## 49
## 116
## 110
## 158
## 115
## 182
## 191
## 111
## 109
## 157
## 149
## 216
## 210
## 258
## 215
## 282
## 291
## 211
## 209
## 257
## 249  186.6203
## 316 2401.7380 2612.3993
## 310 2247.9064 2370.5147  186.4061
## 358 2325.9322 2540.0938  169.4218  189.2728
## 315 2251.8321 2372.8624  185.5520  193.8454  190.3676
## 382 2225.4213 2309.8813  198.8966  201.1588  216.2667  180.9743
## 391 2426.4880 2583.1068  156.3046  174.6910  173.6105  195.3691  198.9028
## 311 2399.7135 2597.7707  187.8287  192.8147  176.6124  198.7769  208.5011
## 309 1719.8777 1806.0652  241.0633  204.0337  251.9073  211.2741  233.0564
## 357 1356.3945 1404.4864  367.9550  274.1337  352.4757  281.7031  268.8086
## 349 1462.4936 1513.5269  303.8218  272.1534  308.0630  224.8090  241.3437
## 416  255.7374  307.1740 1767.2225 1628.7882 1707.1044 1672.0597 1595.2665
## 410  236.4893  240.7972 1699.1602 1507.1122 1678.9767 1546.5208 1465.2624
## 458  274.6402  280.2280 2069.4549 1811.6985 1990.1648 1809.3364 1765.6519
## 415  237.6159  243.3973 1862.5001 1728.6196 1819.2683 1778.4143 1683.5221
## 482  288.6771  287.0789 1939.1338 1709.1882 1867.8551 1700.8454 1648.9072
## 491  389.4303  424.5677 1291.5400 1197.7365 1252.8502 1202.7189 1191.2611
## 411  298.0642  371.0819 1437.9718 1332.4802 1379.6890 1362.1360 1318.1805
## 409  262.3540  291.0509 1857.1196 1757.4864 1799.6455 1764.8963 1711.9882
## 457  265.1150  259.2030 2269.0156 2013.6411 2208.7066 2003.9452 1946.9169
## 449  260.7436  283.1933 2133.6876 1994.2284 2063.2260 1981.4581 1946.2202
## 516 1598.4254 1739.8372  336.9541  302.4338  333.1101  306.5733  300.3013
## 510 1251.6997 1304.5152  428.8973  360.0278  437.5025  375.8806  364.6204
## 558 1066.1918 1123.3298  459.5980  385.9800  467.2663  382.7908  370.0220
## 515 1598.6731 1768.6542  395.9807  338.3058  365.1944  304.5471  336.3361
## 582 1812.3080 1873.1539  338.7678  318.0229  345.8794  288.0557  271.3779
## 591 1426.0531 1567.0481  355.0474  309.7662  340.7427  283.4909  283.3660
```

511 1476.4259 1560.8842 360.3773 338.2268 367.6958 293.2159 301.0897
509 1466.9181 1609.6692 324.4792 307.9878 313.7574 286.1064 285.4719
557 1348.9734 1346.4313 439.5722 365.1693 456.9742 358.7957 338.4169
549 1708.1607 1837.5243 354.3086 343.4559 360.5399 339.4429 355.7887
391   311   309   357   349   416   410
10
58
15
82
91
11
9
57
49
116
110
158
115
182
191
111
109
157
149
216
210
258
215
282
291
211
209
257
249
316
310
358
315
382
391
311 180.9067
309 239.2966 225.1823
357 311.4097 360.8554 193.2415
349 298.7071 300.5772 184.4269 179.8640
416 1773.9031 1769.6936 1264.6615 956.4412 1057.2574
410 1698.7998 1709.4247 1153.4108 886.5442 968.8306 238.8364
458 2018.9767 2037.7941 1367.4596 1075.1067 1147.1902 228.4807 184.2529
415 1885.2824 1877.0779 1344.9249 1023.7177 1107.1961 183.9756 224.5038
482 1884.5055 1919.4286 1260.2230 969.7392 1063.4223 184.9524 196.6786
491 1360.6643 1324.9295 899.3018 734.9139 869.5993 282.6441 369.2314
411 1471.9809 1468.8738 1038.2352 791.4835 891.0855 191.7580 294.8490
409 1907.7182 1892.3444 1378.5712 1082.5053 1157.5906 179.9284 200.7810
457 2262.8463 2247.7302 1527.5828 1202.6683 1256.8377 263.4201 171.9886
449 2137.2675 2144.1763 1502.0909 1188.0568 1261.5096 223.7616 184.8163
516 321.5376 321.9363 256.5804 295.0870 251.9803 1156.5693 1099.2251
510 417.1986 427.9620 233.9889 222.8659 217.9916 889.6169 810.2666
558 423.0234 455.0035 230.9871 184.8549 213.5916 738.7346 686.6547
515 359.6968 369.3802 260.9424 276.4925 250.0588 1137.8400 1129.6823
582 327.8226 314.1053 268.8427 314.6790 260.6628 1357.6906 1225.6823
591 325.0655 332.8270 216.6676 236.5685 233.1903 976.7311 1108.2934
511 362.0831 364.4719 228.5629 245.0669 200.1102 1054.6648 994.4526
509 317.1559 299.2519 236.6151 260.2224 236.6937 1022.6318 1053.5476
557 411.7381 436.5378 252.2899 209.3507 205.1107 914.8850 892.4761
549 346.4923 329.0408 353.1266 414.8373 367.8390 1227.0337 1289.0398

```
##           458       415       482       491       411       409       457
## 10
## 58
## 15
## 82
## 91
## 11
## 9
## 57
## 49
## 116
## 110
## 158
## 115
## 182
## 191
## 111
## 109
## 157
## 149
## 216
## 210
## 258
## 215
## 282
## 291
## 211
## 209
## 257
## 249
## 316
## 310
## 358
## 315
## 382
## 391
## 311
## 309
## 357
## 349
## 416
## 410
## 458
## 415  223.9141
## 482  195.4737  188.4165
## 491  350.5414  314.5157  319.6894
## 411  297.3975  208.5018  252.4904  199.8641
## 409  205.6861  165.9211  199.2893  308.4925  228.6487
## 457  226.6942  249.2783  214.9593  430.3002  332.6068  225.8847
## 449  180.0448  196.3687  175.9837  368.5786  290.1385  193.5615  199.1473
## 516 1365.7275 1217.7682 1258.2175  834.5801  907.7636 1233.8374 1498.0758
## 510  993.3991  951.9124  899.7473  669.4285  720.0009 1003.1836 1105.4048
## 558  890.2236  807.9556  774.5303  521.9306  572.4532  870.6864  963.7964
## 515 1396.7561 1210.4896 1273.0072  811.4351  879.1442 1231.5203 1537.3679
## 582 1446.2340 1427.7705 1331.3975  989.7157 1103.1860 1469.4486 1557.7589
## 591 1210.7005 1074.8905 1084.8345  718.2944  752.1709 1088.4293 1420.1635
## 511 1189.3564 1122.1569 1079.5742  751.2923  801.3940 1153.2178 1311.7027
## 509 1271.6178 1124.0013 1139.8045  747.4206  799.8171 1142.0112 1412.8123
## 557 1042.0080  999.4399  949.7769  771.7427  765.5957 1037.8850 1135.6725
## 549 1467.8950 1316.7982 1342.4728  918.3700  984.8253 1329.5944 1661.4419
##           449       516       510       558       515       582       591
## 10
## 58
## 15
```

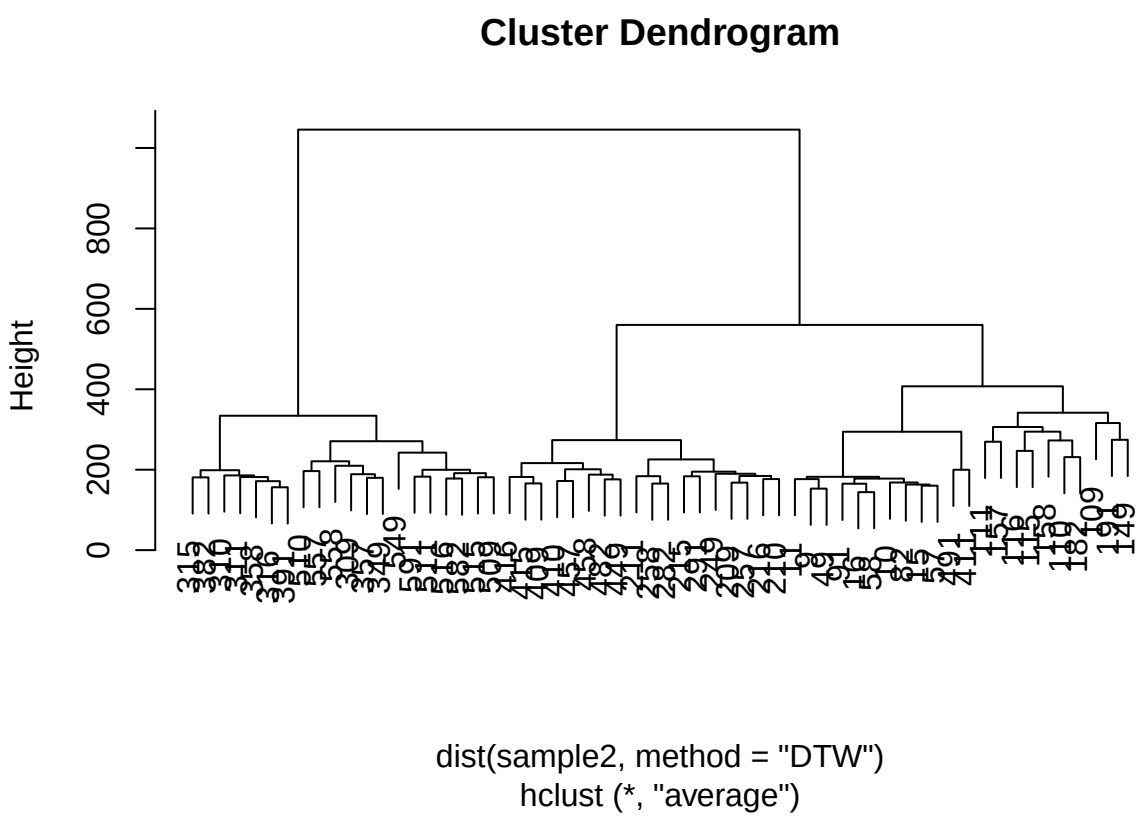
```
## 82
## 91
## 11
## 9
## 57
## 49
## 116
## 110
## 158
## 115
## 182
## 191
## 111
## 109
## 157
## 149
## 216
## 210
## 258
## 215
## 282
## 291
## 211
## 209
## 257
## 249
## 316
## 310
## 358
## 315
## 382
## 391
## 311
## 309
## 357
## 349
## 416
## 410
## 458
## 415
## 482
## 491
## 411
## 409
## 457
## 449
## 516 1443.2426
## 510 1094.6853  239.8513
## 558  969.2235  295.3539  214.8268
## 515 1427.7966  184.9936  220.9261  259.4805
## 582 1576.2604  178.0676  282.8236  322.0392  186.9727
## 591 1261.3511  191.9173  244.3763  254.0292  197.7058  214.1429
## 511 1290.9843  209.9871  209.5292  237.6061  182.6784  214.3165  182.7114
## 509 1309.5127  185.7424  212.0275  257.4121  181.2420  207.8011  203.4438
## 557 1137.2228  268.4579  196.5879  211.1711  256.3025  281.0986  255.7545
## 549 1532.0960  211.7532  347.3877  392.3697  244.3941  250.8419  234.8534
##           511       509       557
## 10
## 58
## 15
## 82
## 91
## 11
## 9
```

```
## 57
## 49
## 116
## 110
## 158
## 115
## 182
## 191
## 111
## 109
## 157
## 149
## 216
## 210
## 258
## 215
## 282
## 291
## 211
## 209
## 257
## 249
## 316
## 310
## 358
## 315
## 382
## 391
## 311
## 309
## 357
## 349
## 416
## 410
## 458
## 415
## 482
## 491
## 411
## 409
## 457
## 449
## 516
## 510
## 558
## 515
## 582
## 591
## 511
## 509  184.0914
## 557  208.9702  266.4586
## 549  284.5245  228.3851  399.2930
```

```
hclust(dist(sample2, method = 'DTW'), method = 'average')
```

```
##
## Call:
## hclust(d = dist(sample2, method = "DTW"), method = "average")
##
## Cluster method   : average
## Distance         : DTW
## Number of objects: 60
```

```
plot(hclust(dist(sample2, method = 'DTW'), method = 'average'))
```



4. Time Series Classification

Exercise

1. Import economic_data.csv ke dalam R.
2. Takrifkan data kepada format siri masa iaitu ianya adalah data bulanan bermula Januari 2000.
3. Plotkan siri masa tersebut.
4. Kenalpasti dan suaikan model ARIMA yang sesuai terhadap data.
5. Jalan peramalan terhadap data untuk 24 bulan seterusnya.
6. Plotkan peramalan bersama selang keyakinan.

Read data (economic_data)

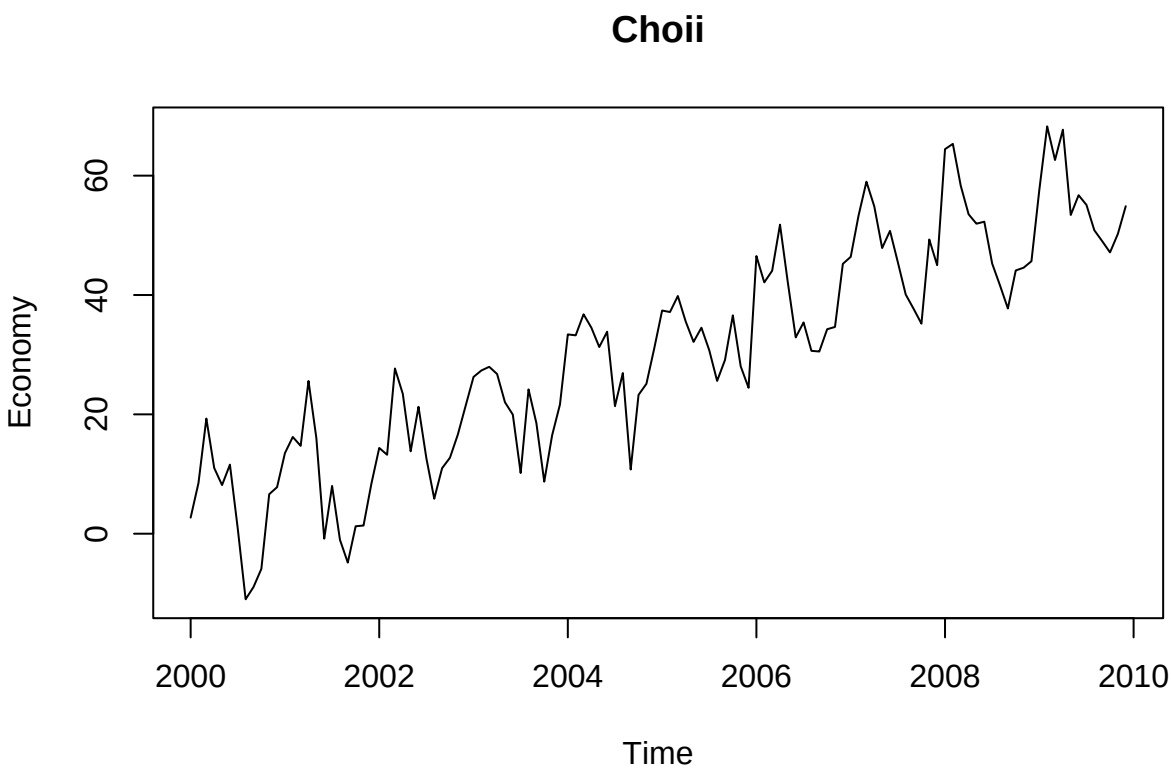
```
eco_data <- read.csv('./Data/economic_data.csv', sep = ';')
head(eco_data)
```

```
##   Time Economic_Data.x
## 1    1        2.697622
## 2    2        8.509367
## 3    3       19.293542
## 4    4       11.012796
## 5    5        8.146439
## 6    6       11.575325
```

```
eco_ts <- ts(eco_data[,2], start = c(2000,1), frequency = 12)
head(eco_ts)
```

```
##            Jan       Feb       Mar       Apr       May       Jun
## 2000  2.697622  8.509367 19.293542 11.012796  8.146439 11.575325
```

```r
plot.ts(eco_ts, main = 'Choii', xlab = 'Time', ylab = 'Economy')
```




```r
eco_model <- auto.arima(eco_ts)
summary(eco_model)
```

```
## Series: eco_ts
## ARIMA(0,0,0)(0,1,2)[12] with drift
##
## Coefficients:
##          sma1    sma2   drift
##       -1.0488  0.1765  0.4944
## s.e.   0.1606  0.1148  0.0109
##
## sigma^2 = 21.76:  log likelihood = -327.72
## AIC=663.44   AICc=663.82   BIC=674.16
##
## Training set error measures:
##                       ME     RMSE      MAE      MPE     MAPE      MASE
## Training set -0.01724821 4.363728 3.269357 5.841319 32.55449 0.4613457
##                    ACF1
## Training set 0.04087961
```

```r
fcst <- forecast(eco_model)
fcst
```

```
##          Point Forecast    Lo 80    Hi 80    Lo 95    Hi 95
## Jan 2010       67.94274 61.93164 73.95384 58.74956 77.13592
## Feb 2010       68.73219 62.72109 74.74329 59.53900 77.92537
## Mar 2010       71.89923 65.88814 77.91033 62.70605 81.09242
## Apr 2010       70.53671 64.52561 76.54780 61.34352 79.72989
## May 2010       65.11032 59.09922 71.12142 55.91714 74.30350
## Jun 2010       64.04317 58.03208 70.05427 54.84999 73.23636
## Jul 2010       58.94314 52.93204 64.95424 49.74996 68.13632
## Aug 2010       56.22022 50.20913 62.23132 47.02704 65.41341
```

```
## Sep 2010       53.67621 47.66511 59.68731 44.48303 62.86939
## Oct 2010       57.05715 51.04605 63.06825 47.86397 66.25033
## Nov 2010       60.44689 54.43579 66.45799 51.25371 69.64007
## Dec 2010       63.16441 57.15332 69.17551 53.97123 72.35760
## Jan 2011       73.41010 67.40418 79.41602 64.22484 82.59536
## Feb 2011       75.87952 69.87360 81.88544 66.69426 85.06478
## Mar 2011       77.24475 71.23883 83.25067 68.05949 86.43001
## Apr 2011       76.82497 70.81906 82.83089 67.63971 86.01023
## May 2011       70.04293 64.03701 76.04885 60.85767 79.22819
## Jun 2011       69.77046 63.76454 75.77638 60.58520 78.95572
## Jul 2011       65.19121 59.18529 71.19712 56.00595 74.37647
## Aug 2011       62.15852 56.15260 68.16444 52.97326 71.34378
## Sep 2011       59.69520 53.68928 65.70112 50.50994 68.88046
## Oct 2011       62.26348 56.25756 68.26940 53.07822 71.44874
## Nov 2011       65.57543 59.56951 71.58135 56.39017 74.76069
## Dec 2011       68.51200 62.50608 74.51792 59.32674 77.69726
```

```
is.null(eco_model)
```

```
## [1] FALSE
```

```
#eco_U <- fcst$pred+0.69*fcst$se
#eco_L <- fcst$pred-0.69*fcst$se
```

```
#plot(eco_ts, fcst$mean)
```