

# Mining Time Series Data

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2024-12-08

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## 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] "2025-01-05"
```

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

```
##           Jan           Feb           Mar           Apr           May
## 2020      0.084154593 -0.521073316  1.990930981  0.691840104
## 2021 -0.770137260 -0.243918764 -0.102355768 -0.472625014  1.917862134
## 2022  2.128863326 -0.899738147  0.118626491 -0.710738959  0.889749724
## 2023 -0.535203915 -1.238101706  0.346770887 -1.884943256  0.922093036
## 2024  0.406178175 -0.189513017  0.140340942 -0.653859737 -0.378905713
## 2025 -0.016832261
##           Jun           Jul           Aug           Sep           Oct
## 2020 -1.049095384  0.771999171 -0.451812873 -1.114061453 -0.443273947
## 2021  0.137952834 -1.700699169 -0.750583177  0.337950202  1.065139116
## 2022  0.327411956  1.145334883  0.007397906  0.289450312 -0.882458171
## 2023  0.719882749 -0.338642100 -0.339709768  1.273828606 -0.154451283
## 2024 -0.876043862  0.602463543 -1.619409039  1.569733466  0.385418918
## 2025
##           Nov           Dec
## 2020 -0.961971059 -0.246167911
```

```
## 2021 0.277553375 0.401715756
## 2022 -0.366986555 -0.632746885
## 2023 -0.754359936 -0.223683583
## 2024 0.051492638 0.228229264
## 2025
```

```
dates_format <- read.csv('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
```

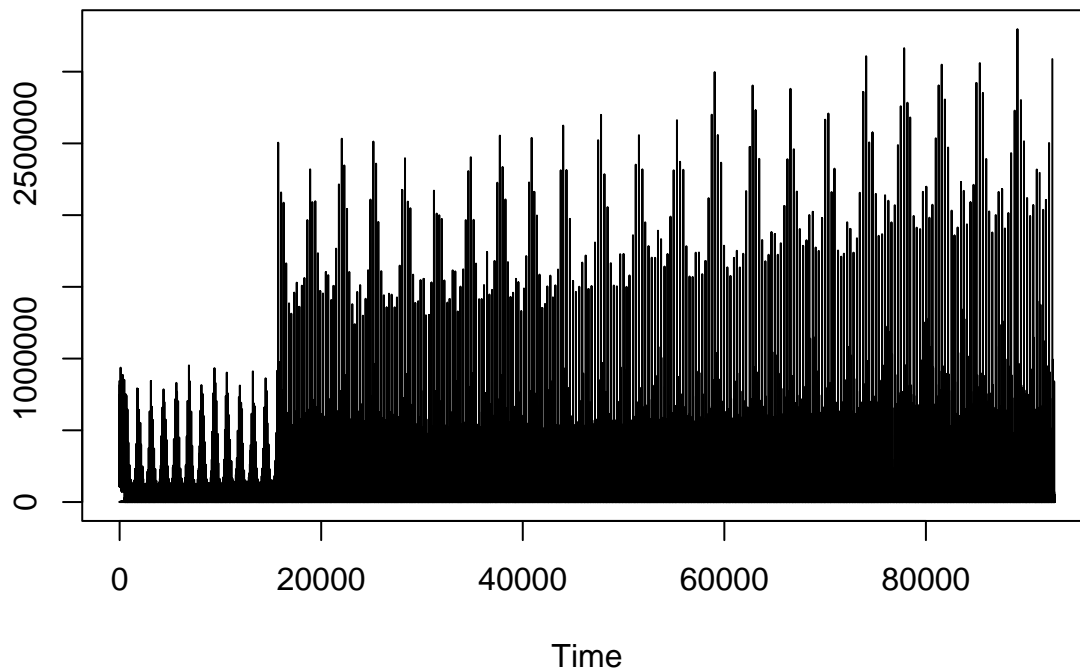
```
## Japanese_format US_format CA_mix_format SA_mix_format NZ_format
## 1 2017-01-20 1/20/2017 January 20, 2017 20 January 2017 20/01/2017
## 2 2017-01-21 1/21/2017 January 21, 2017 21 January 2017 21/01/2017
## 3 2017-01-22 1/22/2017 January 22, 2017 22 January 2017 22/01/2017
## 4 2017-01-23 1/23/2017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

### 2.1 Additive Decomposition

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



```
data(USVsales)
```

```
## Warning in data(USVsales): data set 'USVsales' not found
```

## 2.2 Multiplicative Decomposition

## 2. Time Series Forecasting

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

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

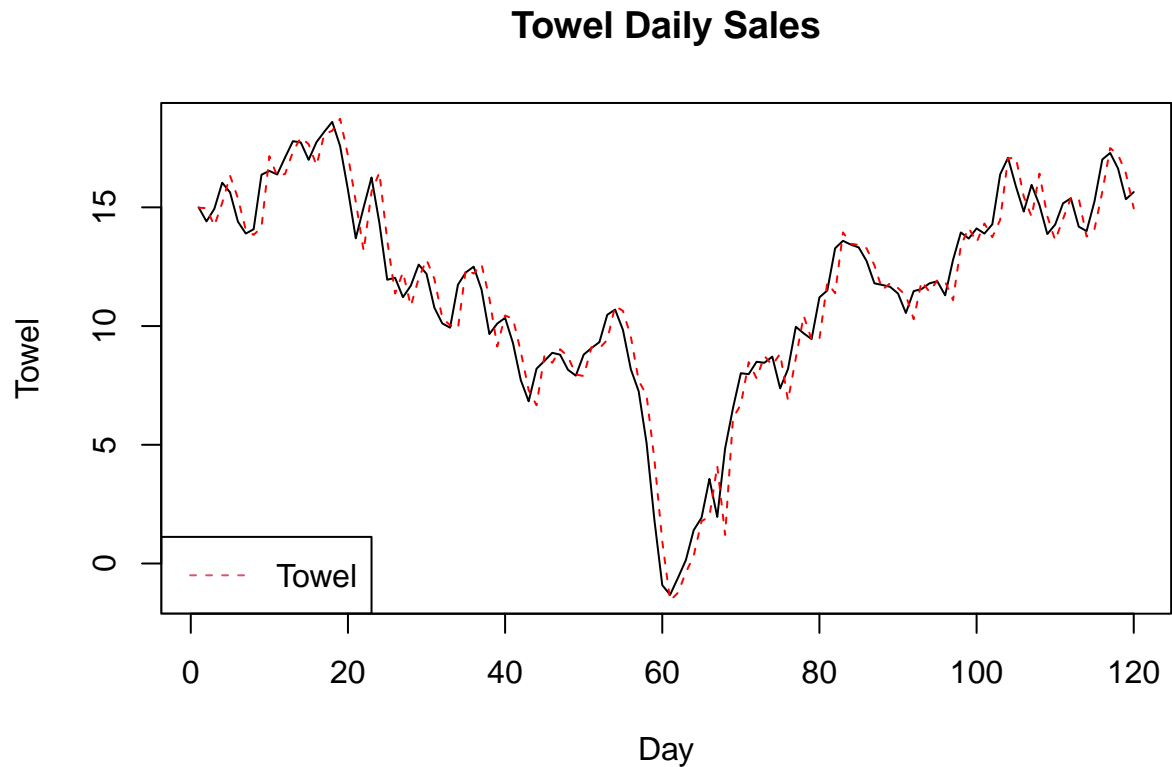
```
head(ts(towel))
```

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

```
library(forecast)
```

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

```
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,

```
##
## 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
```

##	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

##	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

```
## $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('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)
```

```
## Loading required package: proxy
```

```
##
```

```
## Attaching package: 'proxy'
```

```
## The following objects are masked from 'package:stats':
```

```
##
```

```
## as.dist, dist
```

```
## The following object is masked from 'package:base':
```

```
##
```

```
## as.matrix
```

```
## Loaded dtw v1.23-1. See ?dtw for help, citation("dtw") for use in publication.
```

```
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
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## 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
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## 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
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## 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
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##	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

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## 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							
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## 182							
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## 109							
## 157							
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## 216							
## 210							
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## 215							
## 282							
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## 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
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## 15
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```

## 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  
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## 409  
## 457  
## 449

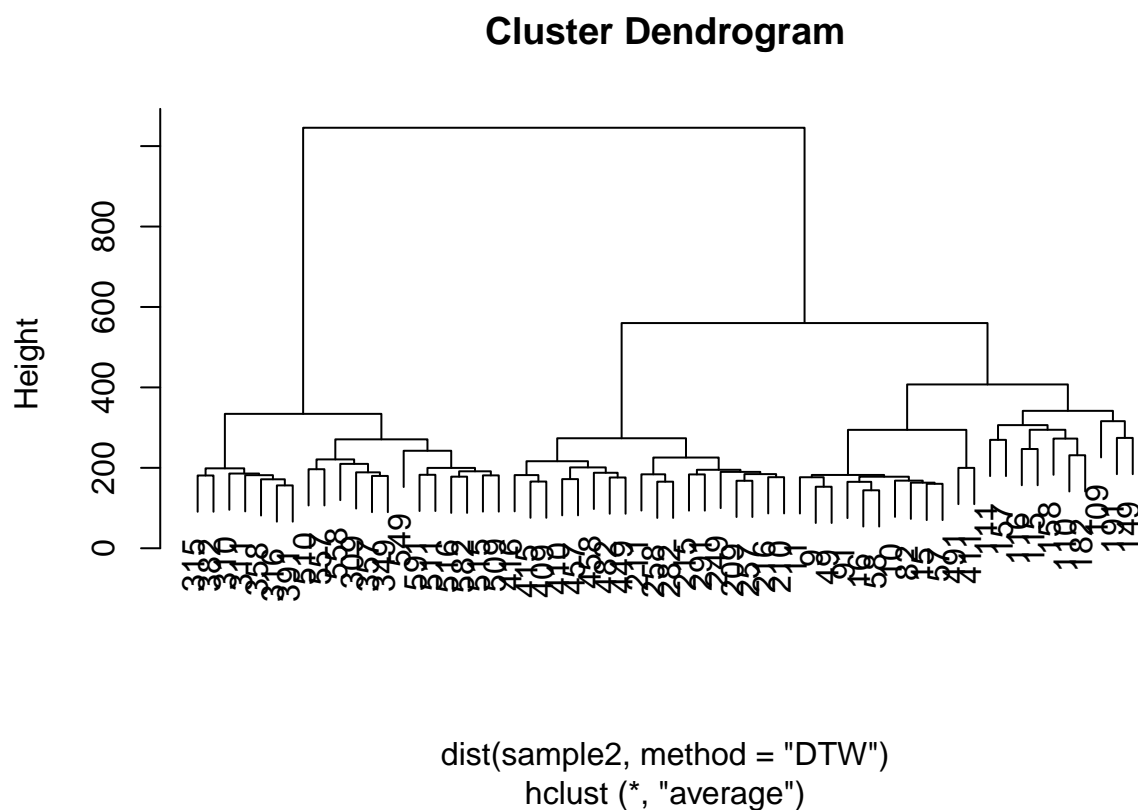


```
## 516
## 510
## 558
## 515
## 582
## 591
## 511
## 509 184.0914
## 557 208.9702 266.4586
## 549 284.5245 228.3851 399.2930
```

```
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.

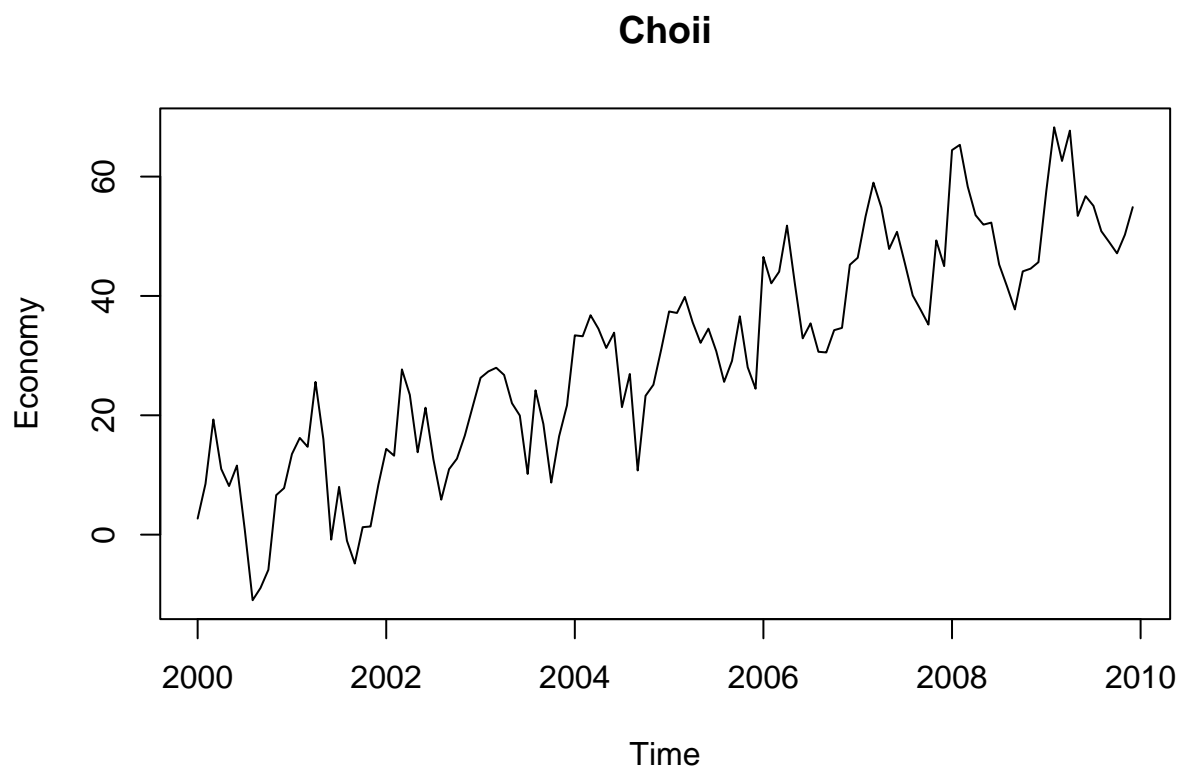
```
eco_data <- read.csv('economic_data.csv', sep = ';')
head(eco_data)
```

```
##      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
```

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



```
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
```

```
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)
```