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title: "Lab 08"

author: "Puskar"

date: "2025-09-03"

output: html\_document

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```{r setup, include=FALSE}

knitr::opts\_chunk$set(echo = TRUE)

```

## R Markdown

This is an R Markdown document. Markdown is a simple formatting syntax for authoring HTML, PDF, and MS Word documents. For more details on using R Markdown see <http://rmarkdown.rstudio.com>.

When you click the \*\*Knit\*\* button a document will be generated that includes both content as well as the output of any embedded R code chunks within the document. You can embed an R code chunk like this:

```{r cars}

> library(forecast)

Error in library(forecast) : there is no package called ‘forecast’

> install.packages("forecast", dependencies = TRUE)

also installing the dependencies ‘xts’, ‘TTR’, ‘curl’, ‘pkgbuild’, ‘rprojroot’, ‘diffobj’, ‘quadprog’, ‘quantmod’, ‘x13binary’, ‘brio’, ‘callr’, ‘desc’, ‘pkgload’, ‘praise’, ‘processx’, ‘ps’, ‘waldo’, ‘colorspace’, ‘fracdiff’, ‘lmtest’, ‘tseries’, ‘urca’, ‘zoo’, ‘RcppArmadillo’, ‘forecTheta’, ‘rticles’, ‘seasonal’, ‘testthat’, ‘uroot’

trying URL 'https://cran.rstudio.com/bin/macosx/big-sur-arm64/contrib/4.5/xts\_0.14.1.tgz'

trying URL 'https://cran.rstudio.com/bin/macosx/big-sur-arm64/contrib/4.5/TTR\_0.24.4.tgz'

trying URL 'https://cran.rstudio.com/bin/macosx/big-sur-arm64/contrib/4.5/curl\_7.0.0.tgz'

trying URL 'https://cran.rstudio.com/bin/macosx/big-sur-arm64/contrib/4.5/pkgbuild\_1.4.8.tgz'

trying URL 'https://cran.rstudio.com/bin/macosx/big-sur-arm64/contrib/4.5/rprojroot\_2.1.1.tgz'

trying URL 'https://cran.rstudio.com/bin/macosx/big-sur-arm64/contrib/4.5/diffobj\_0.3.6.tgz'

trying URL 'https://cran.rstudio.com/bin/macosx/big-sur-arm64/contrib/4.5/quadprog\_1.5-8.tgz'

trying URL 'https://cran.rstudio.com/bin/macosx/big-sur-arm64/contrib/4.5/quantmod\_0.4.28.tgz'

trying URL 'https://cran.rstudio.com/bin/macosx/big-sur-arm64/contrib/4.5/x13binary\_1.1.61.1.tgz'

trying URL 'https://cran.rstudio.com/bin/macosx/big-sur-arm64/contrib/4.5/brio\_1.1.5.tgz'

trying URL 'https://cran.rstudio.com/bin/macosx/big-sur-arm64/contrib/4.5/callr\_3.7.6.tgz'

trying URL 'https://cran.rstudio.com/bin/macosx/big-sur-arm64/contrib/4.5/desc\_1.4.3.tgz'

trying URL 'https://cran.rstudio.com/bin/macosx/big-sur-arm64/contrib/4.5/pkgload\_1.4.0.tgz'

trying URL 'https://cran.rstudio.com/bin/macosx/big-sur-arm64/contrib/4.5/praise\_1.0.0.tgz'

trying URL 'https://cran.rstudio.com/bin/macosx/big-sur-arm64/contrib/4.5/processx\_3.8.6.tgz'

trying URL 'https://cran.rstudio.com/bin/macosx/big-sur-arm64/contrib/4.5/ps\_1.9.1.tgz'

trying URL 'https://cran.rstudio.com/bin/macosx/big-sur-arm64/contrib/4.5/waldo\_0.6.2.tgz'

trying URL 'https://cran.rstudio.com/bin/macosx/big-sur-arm64/contrib/4.5/colorspace\_2.1-1.tgz'

trying URL 'https://cran.rstudio.com/bin/macosx/big-sur-arm64/contrib/4.5/fracdiff\_1.5-3.tgz'

trying URL 'https://cran.rstudio.com/bin/macosx/big-sur-arm64/contrib/4.5/lmtest\_0.9-40.tgz'

trying URL 'https://cran.rstudio.com/bin/macosx/big-sur-arm64/contrib/4.5/tseries\_0.10-58.tgz'

trying URL 'https://cran.rstudio.com/bin/macosx/big-sur-arm64/contrib/4.5/urca\_1.3-4.tgz'

trying URL 'https://cran.rstudio.com/bin/macosx/big-sur-arm64/contrib/4.5/zoo\_1.8-14.tgz'

trying URL 'https://cran.rstudio.com/bin/macosx/big-sur-arm64/contrib/4.5/RcppArmadillo\_14.6.3-1.tgz'

trying URL 'https://cran.rstudio.com/bin/macosx/big-sur-arm64/contrib/4.5/forecTheta\_3.0.tgz'

trying URL 'https://cran.rstudio.com/bin/macosx/big-sur-arm64/contrib/4.5/rticles\_0.27.tgz'

trying URL 'https://cran.rstudio.com/bin/macosx/big-sur-arm64/contrib/4.5/seasonal\_1.10.0.tgz'

trying URL 'https://cran.rstudio.com/bin/macosx/big-sur-arm64/contrib/4.5/testthat\_3.2.3.tgz'

trying URL 'https://cran.rstudio.com/bin/macosx/big-sur-arm64/contrib/4.5/uroot\_2.1-3.tgz'

trying URL 'https://cran.rstudio.com/bin/macosx/big-sur-arm64/contrib/4.5/forecast\_8.24.0.tgz'

The downloaded binary packages are in

/var/folders/v\_/7dgqf6xx1y30mhhjz64drcqm0000gn/T//RtmpIXCn0P/downloaded\_packages

>

> library(forecast)

Registered S3 method overwritten by 'quantmod':

method from

as.zoo.data.frame zoo

> co2<-read.csv("co2Month.csv")

Error in file(file, "rt") : cannot open the connection

In addition: Warning message:

In file(file, "rt") :

cannot open file 'co2Month.csv': No such file or directory

> getwd()

[1] "/Users/puskar/Lab work 8"

> library(forecast)

> co2<-read.csv("co2Month.csv")

> tsCo2 <- ts(co2$CO2ppm, start=1959, frequency=12)

> plot(tsCo2)

> sum(is.na(tsCo2))

[1] 0

> m<-ma(tsCo2, 20)

> lines(m, col="red") #moving average smoothing

> autoplot(forecast(tsCo2, 10))

> head(cbind(tsCo2, m))

tsCo2 m

Jan 1959 315.58 NA

Feb 1959 316.48 NA

Mar 1959 316.65 NA

Apr 1959 317.72 NA

May 1959 318.29 NA

Jun 1959 318.15 NA

> #ma retain autocorrelation hist, shapiro

> acf(res, main="ACF of residuals")

Error: object 'res' not found

> # Fit an ARIMA model

> fit <- auto.arima(tsCo2)

>

> # Get residuals

> res <- residuals(fit)

>

> # Plot ACF of residuals

> acf(res, main = "ACF of residuals")

>

> # Fit an ARIMA model

> fit <- auto.arima(tsCo2)

>

> # Get residuals

> res <- residuals(fit)

>

> # Plot ACF of residuals

> acf(res, main = "ACF of residuals")

> # Histogram of residuals

> hist(res, main = "Histogram of residuals", xlab = "Residuals")

>

> # Shapiro-Wilk normality test

> shapiro.test(res)

Shapiro-Wilk normality test

data: res

W = 0.99755, p-value = 0.4001

>

> # Histogram of residuals

> hist(res, main = "Histogram of residuals", xlab = "Residuals")

>

> # Shapiro-Wilk normality test

> shapiro.test(res)

Shapiro-Wilk normality test

data: res

W = 0.99755, p-value = 0.4001

>

> pcErr #ia this an acceptable error?

Error: object 'pcErr' not found

> mean(pcErr, na.rm = TRUE) # average percentage error

Error: object 'pcErr' not found

> fit <- auto.arima(tsCo2)

> fcast <- forecast(fit, h = 12)

>

> # Calculate percentage errors

> pcErr <- (residuals(fit) / tsCo2) \* 100

>

> fit <- auto.arima(tsCo2)

> fcast <- forecast(fit, h = 12)

>

> # Calculate percentage errors

> pcErr <- (residuals(fit) / tsCo2) \* 100

>

> View(fcast)

> View(co2)

> View(fit)

> #Shows how to add time series linear model

> fit<-tslm(tsCo2~time(tsCo2))

> plot(tsCo2, col=23, main="Co2 with Linear Model fitted")

> lines(fit$fitted.values)

> acf(tsCo2)

> tseries::adf.test(tsCo2)

Augmented Dickey-Fuller Test

data: tsCo2

Dickey-Fuller = -0.45969, Lag order = 8,

p-value = 0.9837

alternative hypothesis: stationary

>

> plot(diff(tsCo2))

> plot(decompose(tsCo2))

> library(forecast)

> co2<-read.csv("AustGovTS.csv")

> tsCo2 <- ts(co2$CO2ppm, start=1959, frequency=12)

Error in ts(co2$CO2ppm, start = 1959, frequency = 12) :

'ts' object must have one or more observations

> library(forecast)

> govAus<-read.csv("AustGovTS.csv")

> tsgovAus <- ts(govAus$govAusppm, start=1959, frequency=12)

Error in ts(govAus$govAusppm, start = 1959, frequency = 12) :

'ts' object must have one or more observations

> head(govAus)

Month total

1 Jan-12 59000

2 Feb-12 600012

3 Mar-12 592314

4 Apr-12 479557

5 May-12 577338

6 Jun-12 524867

> data <- read.csv("govAus.csv")

Error in file(file, "rt") : cannot open the connection

In addition: Warning message:

In file(file, "rt") :

cannot open file 'govAus.csv': No such file or directory

> getwd()

[1] "/Users/puskar/Lab work 8"

> data <- read.csv("AustGovTS.csv")

>

> data$Month <- as.Date(paste0("01-", data$Month), format="%d-%b-%y")

>

> ts\_total <- ts(data$total, start=c(2012,1), frequency=12)

>

> plot(ts\_total, main="Monthly Total", ylab="Total", xlab="Time")

>

> library(forecast)

> m <- ma(ts\_total, 3) # 3-month moving average

> lines(m, col="red")

> fit <- auto.arima(ts\_total)

> fcast <- forecast(fit, h=6) # forecast next 6 months

> autoplot(fcast)

>

> # Fit Holt-Winters model (additive trend and seasonality)

> hw\_fit <- HoltWinters(ts\_total, seasonal="additive")

Warning message:

In HoltWinters(ts\_total, seasonal = "additive") :

optimization difficulties: ERROR: ABNORMAL\_TERMINATION\_IN\_LNSRCH

>

> # Plot fitted model

> plot(hw\_fit, main="Holt-Winters Fit")

>

> # Forecast 10 periods ahead

> hw\_forecast <- forecast(hw\_fit, h=10)

>

> # Plot forecast

> autoplot(hw\_forecast) +

+ ggtitle("Holt-Winters Forecast") +

+ ylab("Total") + xlab("Time")

Error in ggtitle("Holt-Winters Forecast") :

could not find function "ggtitle"

> library(ggplot2)

>

> autoplot(hw\_forecast) +

+ ggtitle("Holt-Winters Forecast") +

+ ylab("Total") +

+ xlab("Time")

>

> plot(hw\_forecast, main="Holt-Winters Forecast", ylab="Total", xlab="Time")

>

> # -----------------------------

> # Holt-Winters Forecast Workflow

> # -----------------------------

>

> # 1️⃣ Read your CSV

> data <- read.csv("yourfile.csv") # replace with your CSV file

Error in file(file, "rt") : cannot open the connection

In addition: Warning message:

In file(file, "rt") :

cannot open file 'yourfile.csv': No such file or directory

> # -----------------------------

> # Holt-Winters Forecast Workflow

> # -----------------------------

>

> # 1️⃣ Read your CSV

> data <- read.csv("govAus.csv")

Error in file(file, "rt") : cannot open the connection

In addition: Warning message:

In file(file, "rt") :

cannot open file 'govAus.csv': No such file or directory

> # -----------------------------

> # Holt-Winters Forecast Workflow

> # -----------------------------

>

> # 1️⃣ Read your CSV

> data <- read.csv("AustGovTS.csv")

> # Check the first rows

> head(data)

Month total

1 Jan-12 59000

2 Feb-12 600012

3 Mar-12 592314

4 Apr-12 479557

5 May-12 577338

6 Jun-12 524867

>

> # 2️⃣ Create a time series

>

> ts\_total <- ts(data$total, start=c(2012,1), frequency=12) # adjust start year/month

>

> # 3️⃣ Plot the original series

> plot(ts\_total, main="Original Time Series", ylab="Total", xlab="Time", col="blue")

>

> # 4️⃣ Fit a linear trend model

> fit\_lm <- tslm(ts\_total ~ time(ts\_total))

> lines(fit\_lm$fitted.values, col="red", lwd=2)

> legend("topleft", legend=c("Original","Linear Trend"), col=c("blue","red"), lwd=2)

>

> # 5️⃣ Evaluate linear model accuracy

> accuracy(fit\_lm)

ME RMSE MAE

Training set 2.177147e-11 73635.45 52511.67

MPE MAPE MASE

Training set -5.664788 12.3573 0.8162273

ACF1

Training set 0.002621963

>

> # 6️⃣ Simple Moving Average (SMA)

> library(forecast)

> sma3 <- ma(ts\_total, order=3)

> plot(ts\_total, main="SMA vs SES", ylab="Total", xlab="Time", col="black")

> lines(sma3, col="blue", lwd=2)

>

> # 7️⃣ Simple Exponential Smoothing (SES)

> ses\_fit <- ses(ts\_total, alpha=0.2, initial="simple")

> lines(ses\_fit$fitted, col="red", lwd=2)

> legend("topleft", legend=c("Original","SMA","SES"), col=c("black","blue","red"), lwd=2)

>

> # Compare accuracy

> accuracy(sma3, ts\_total) # SMA accuracy (may have NAs at start)

ME RMSE MAE MPE

Test set 1655.69 50063.74 38792.02 -0.1576419

MAPE ACF1 Theil's U

Test set 5.34726 -0.4552501 0.3430338

> accuracy(ses\_fit)

ME RMSE MAE MPE

Training set 34793.77 98985.04 67269.06 4.909532

MAPE MASE ACF1

Training set 9.628297 1.045612 0.3381917

>

> # 8️⃣ Holt-Winters (Trend + Seasonal)

> # Use additive model if seasonality is roughly constant

> hw\_fit <- HoltWinters(ts\_total, seasonal="additive")

Warning message:

In HoltWinters(ts\_total, seasonal = "additive") :

optimization difficulties: ERROR: ABNORMAL\_TERMINATION\_IN\_LNSRCH

>

> # Plot fitted Holt-Winters model

> plot(hw\_fit, main="Holt-Winters Fit")

>

> # 9️⃣ Forecast 10 periods ahead

> hw\_forecast <- forecast(hw\_fit, h=10)

>

> # Plot forecast (base R)

> plot(hw\_forecast, main="Holt-Winters Forecast", ylab="Total", xlab="Time")

>

> # 10️⃣ Evaluate Holt-Winters forecast accuracy

> accuracy(hw\_forecast)

ME RMSE MAE MPE

Training set 4980.213 48583.97 37749.42 0.4305512

MAPE MASE ACF1

Training set 5.011135 0.5867669 -0.1137717

>

> wp<-read.csv("data/WPO.csv")

Error in file(file, "rt") : cannot open the connection

In addition: Warning message:

In file(file, "rt") :

cannot open file 'data/WPO.csv': No such file or directory

> wp<-read.csv("WPO.csv")

> wpts<-ts(wp$knots, start=1948, frequency=367)

> ts.plot(wpts, type="l")

> adf.test(wpts)

Error in adf.test(wpts) : could not find function "adf.test"

> library(tseries)

‘tseries’ version: 0.10-58

‘tseries’ is a package for time series

analysis and computational finance.

See ‘library(help="tseries")’ for

details.

>

> # Assuming your CSV is loaded and ts\_wpo is your time series

> # ts\_wpo <- ts(wpo$ColumnName, start=c(2012,1), frequency=12)

>

> adf\_result <- adf.test(ts\_wpo)

Error: object 'ts\_wpo' not found

> library(tseries)

>

> # Assuming your CSV is loaded and ts\_wpo is your time series

> # ts\_wpo <- ts(wpo$ColumnName, start=c(2012,1), frequency=12)

>

> adf\_result <- adf.test(ts\_wpo)

Error: object 'ts\_wpo' not found

> ts\_wpo <- ts(wpo$total, start=c(2012,1), frequency=12) # change start year/month if needed

Error: object 'wpo' not found

> wpo <- read.csv("WPO.csv") # adjust path if needed

> head(wpo)

Year knots

1 1948 97.86

2 1948 132.66

3 1948 190.78

4 1948 238.43

5 1948 186.22

6 1948 110.03

>

> # Create a yearly time series

> ts\_wpo <- ts(wpo$knots, start=min(wpo$Year), frequency=1)

>

> # Check the first few values

> head(ts\_wpo)

Time Series:

Start = 1948

End = 1953

Frequency = 1

[1] 97.86 132.66 190.78 238.43 186.22 110.03

>

> plot(ts\_wpo, main="WPO Knots Time Series", ylab="Knots", xlab="Year", col="blue")

>

> library(tseries)

> adf.test(ts\_wpo)

Augmented Dickey-Fuller Test

data: ts\_wpo

Dickey-Fuller = -21.552, Lag order = 30,

p-value = 0.01

alternative hypothesis: stationary

Warning message:

In adf.test(ts\_wpo) : p-value smaller than printed p-value

>

> #since it is less thab p- value it is stationary.

> library(forecast)

> sma3 <- ma(ts\_wpo, order=3)

> plot(ts\_wpo, main="SMA vs SES", ylab="Knots", xlab="Year", col="black")

> lines(sma3, col="blue", lwd=2)

>

> ses\_fit <- ses(ts\_wpo, alpha=0.2, initial="simple")

> lines(ses\_fit$fitted, col="red", lwd=2)

> legend("topleft", legend=c("Original","SMA","SES"), col=c("black","blue","red"), lwd=2)

>

> ses\_fit <- ses(ts\_wpo, alpha=0.2, initial="simple")

> lines(ses\_fit$fitted, col="red", lwd=2)

> legend("topleft", legend=c("Original","SMA","SES"), col=c("black","blue","red"), lwd=2)

>

> hw\_fit <- HoltWinters(ts\_wpo, beta=TRUE, gamma=FALSE) # Trend only

> plot(hw\_fit, main="Holt-Winters Fit")

> hw\_forecast <- forecast(hw\_fit, h=10) # Forecast next 10 years

> plot(hw\_forecast, main="Holt-Winters Forecast", ylab="Knots", xlab="Year")

```