

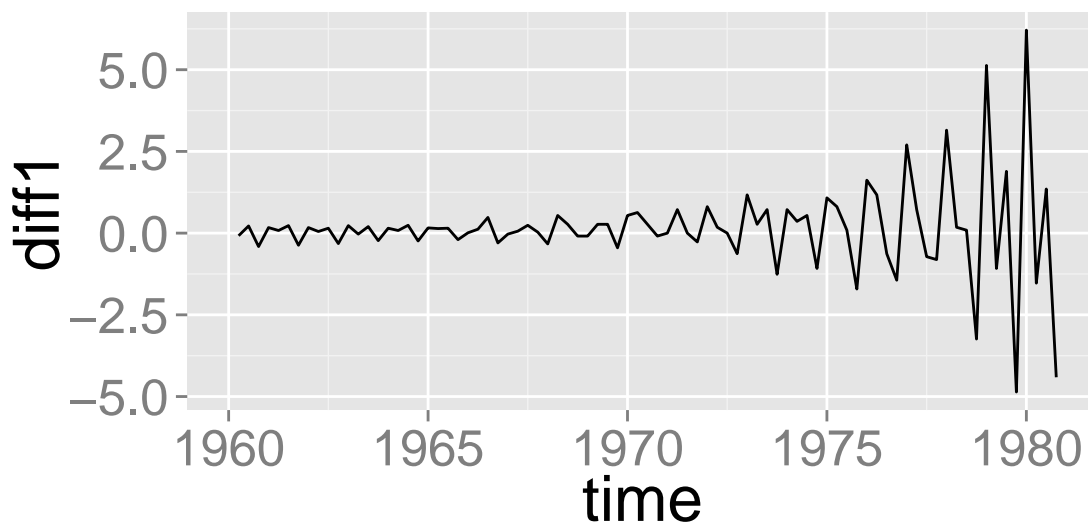
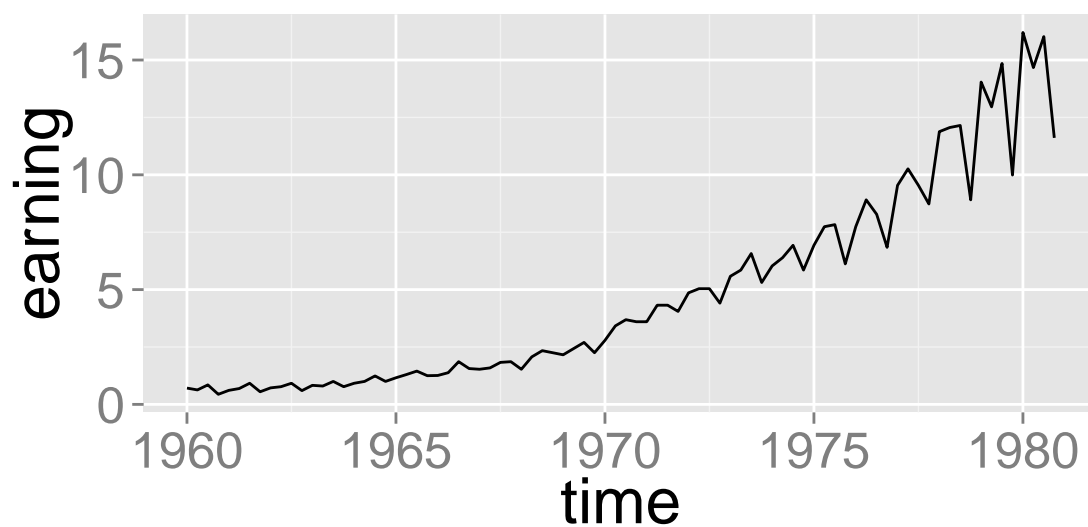
# Homework 5

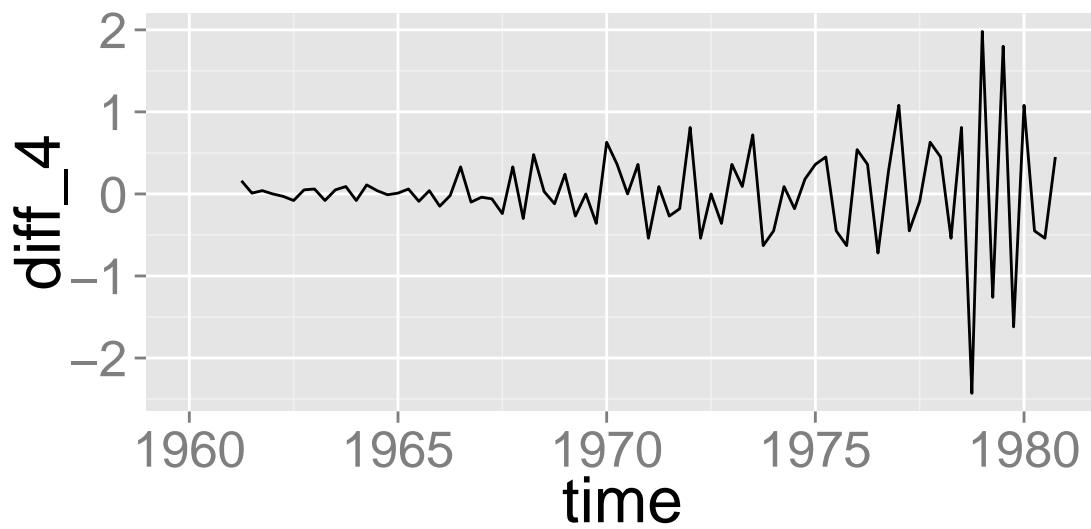
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*February 16, 2016*

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**Fit a seasonal ARIMA model to the Johnson and Johnson quarterly returns**



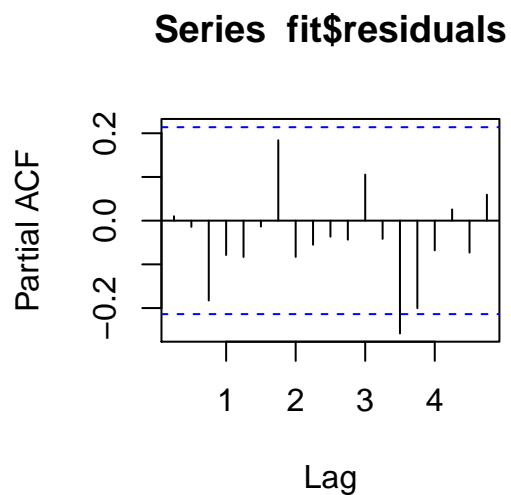
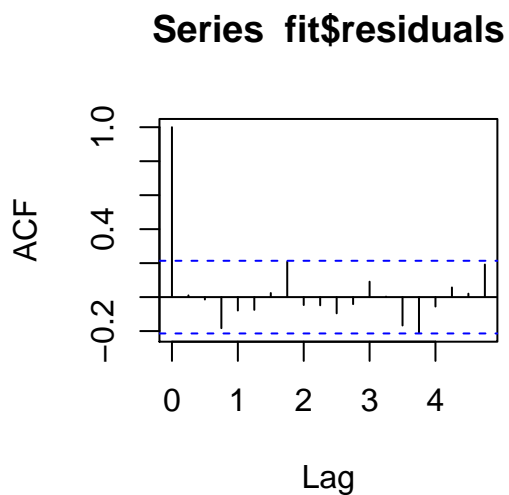


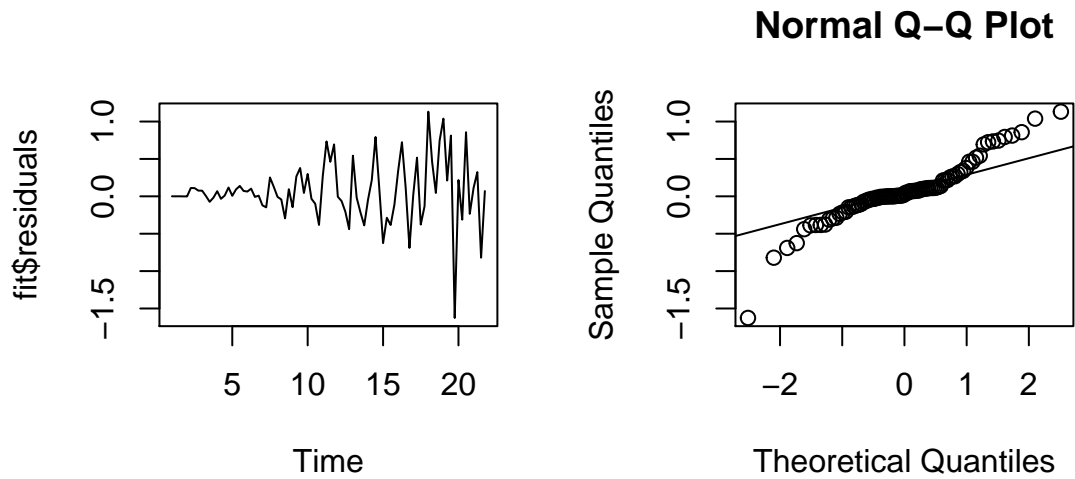
###

Fit model

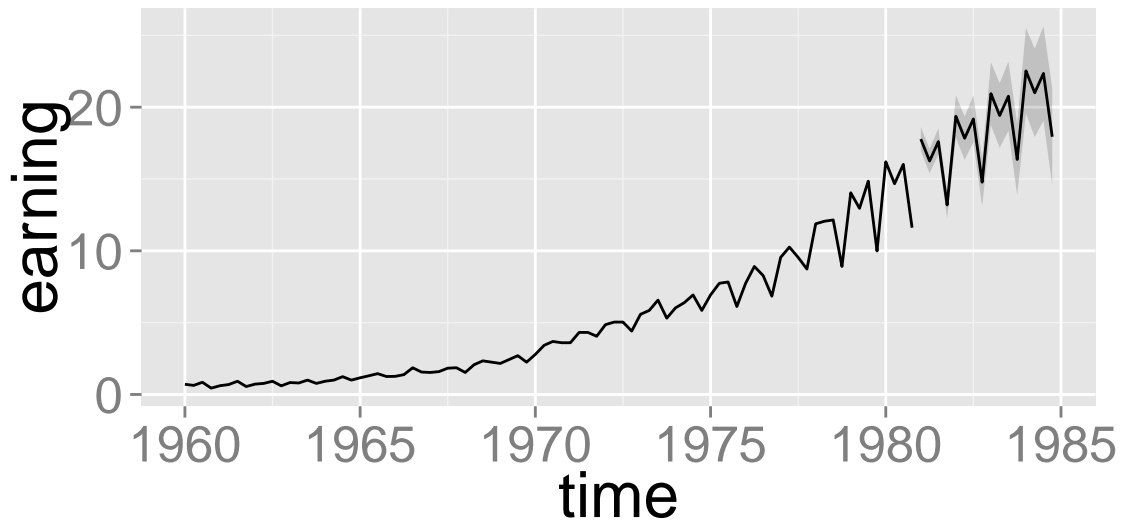
Result from `auto.arima` shows  $ARIM(1,1,2)(0,1,0)_4$  fits the model best. The diagnosis for the model can be shown as.

Diagnosis





###



Forecat

## 2 The Holt Winters Method

**What decisions need to be made to use a Holt Winters forecasting approach? What starting values do you need to specify? What parameters need estimating?**

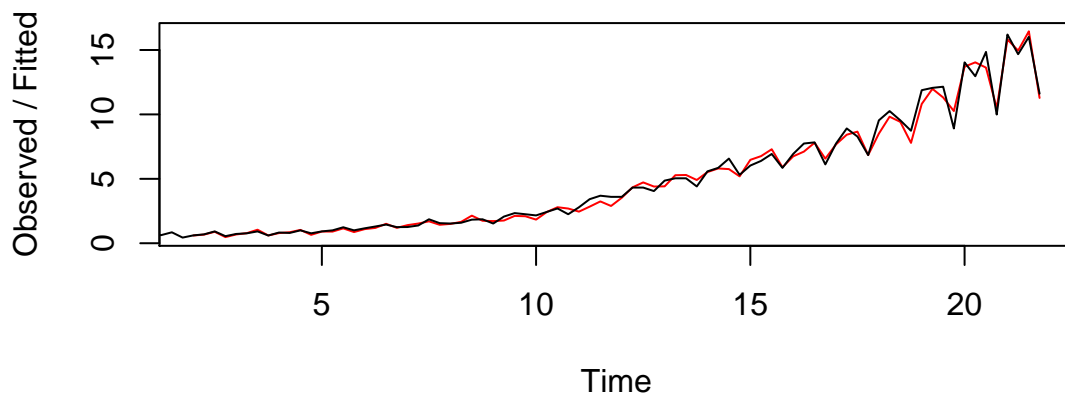
- If the data has trend and seasonality, we use Holt Winters method instead of simple exponential smoothing method.
- Examine a graph of the data to check whether additive or multiplicative is appropriate
- Provide starting value for  $L_1$  and  $T_1$  as well as seasonal value for the first years, using few observations in the series.
- Estimate value of parameters  $\alpha$ ,  $\gamma$ ,  $\sigma$  by minimizing the squared error  $\sum e_t^2$  for the fitted value
- Decide whether to normalize the seasonal indices at regular intervals.
- Choose an automatic or non automatic approach

The starting values that need to be specified are  $L_1$ ,  $T_1$  and seasonal values for the first years. Then  $\alpha$ ,  $\gamma$ ,  $\sigma$  are estimated by minimizing squared error  $\sum e_t^2$ . ### Investigate the R function `HoltWinters`. How do you

specify the decisions from above? How does the function choose starting values and estimate parameters? The R package for Holt-Winter is

Based from the R-package documentation the function choose starting values as follows. For seasonal models, start values for  $a$ ,  $b$  and  $s$  are inferred by performing a simple decomposition in trend and seasonal component using moving averages (see function `decompose`) on the start.periods first periods (a simple linear regression on the trend component is used for starting level and trend). For level/trend-models (no seasonal component), start values for  $a$  and  $b$  are  $x[2]$  and  $x[2] - x[1]$ , respectively. For level-only models (ordinary exponential smoothing), the start value for  $a$  is  $x[1]$ . ### Use the function to produce forecasts (along with prediction intervals) for Johnson and Johnson returns in question 1.

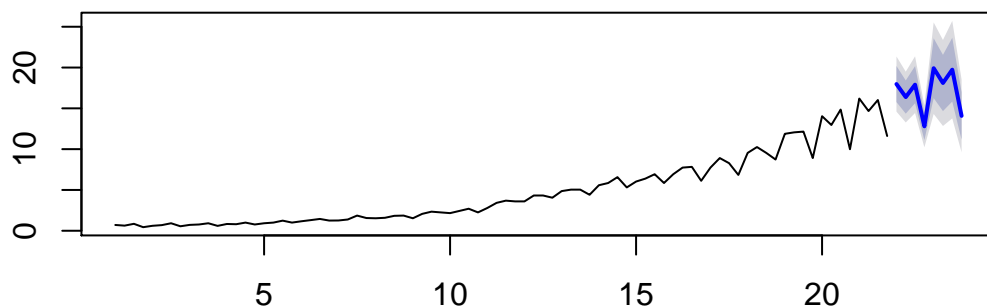
## Holt-Winters filtering



Forecasting using HoltWinters method.

###

## Forecasts from Holt-Winters' multiplicative method



```
knitr::opts_chunk$set(echo=FALSE, message = FALSE,
  warning = FALSE, results = "hide", fig.height = 3, fig.width = 6)
library('astsa')
library('dplyr')
library('ggplot2')
```

```

library('forecast')
big_font <- theme_grey(base_size = 24)
source(url("http://stat565.cwick.co.nz/code/fortify-ts.r"))
data(jj)
jj <- fortify(jj) %>% rename(earning=x)

qplot(time,earning, data = jj, geom = "line") +
  big_font

jj$diff1 <- c(rep(NA,1),diff(jj$earning,lag=1))
qplot(time,diff1,data=jj,geom="line") +big_font

#seasonality
jj$diff_4 <- c(rep(NA, 4), diff(jj$diff1, lag = 4))
qplot(time,diff_4, data = jj, geom = "line") +
  big_font

#fit using auto.arima model
fit <- forecast::auto.arima(jj$diff_4) #this fits ARIMA(1,0,2)
#or simply fitting in the original gives
fit <-forecast::auto.arima(ts(jj$earning,frequency = 4)) # ARIM(1,1,2)(0,1,0)_4
par(mfrow=c(1,2))
acf(fit$residuals)
pacf(fit$residuals)
plot(fit$residuals)
qqnorm(fit$residuals)
qqline(fit$residuals)
pred.df <- as.data.frame(predict(fit, n.ahead = 4*4))
pred.df$time <- max(jj$time) + (1:(4*4))/4

qplot(time, earning, data = jj, geom = "line") +
  geom_ribbon(aes(ymin = pred- 2*se, ymax = pred + 2*se, y = NULL), data = pred.df, alpha = 0.2) +
  geom_line(aes(y = pred), data = pred.df) +
  big_font

HoltWinters(x, alpha = NULL, beta = NULL, gamma = NULL,
  seasonal = c("additive", "multiplicative"),
  start.periods = 2, l.start = NULL, b.start = NULL,
  s.start = NULL,
  optim.start = c(alpha = 0.3, beta = 0.1, gamma = 0.1),
  optim.control = list())

#library('HoltWinters')
hwt <- HoltWinters(ts(jj$earning,frequency = 4), seasonal = "multiplicative", start.periods = 2)
plot(hwt)
#Forecasting
# predict.hw <- predict(hwt,n.ahead = 12, prediction.interval = TRUE, level = 0.95)
# predict.df <- data.frame(predict.hw)
# qplot(time, earning, data = jj, geom = "line") +
#   geom_ribbon(aes(ymin =lwr,ymax =upr, y = NULL), data =pred, alpha = 0.2) +
#   geom_line(aes(y = fit), data = pred.df) +
#   big_font

hw.fit <- hw(ts(jj$earning,frequency = 4), seasonal="multiplicative")
plot(hw.fit)

```