Econometrics-Damodar N. Gujarati / Chapter 22

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Time Series Econometrics:Forecasting

AR, MA, and ARIMA Modeling of Time Series Data

Autoregressive (AR) Process (22.2.1)

$$(Y_t - \delta) = \alpha_1(Y_{t-1} - \delta) + u_t$$

Pth-order Autoregressive - AR(p) (22.2.3)

$$(Y_t - \delta) = \alpha_1(Y_{t-1} - \delta) + \alpha_2(Y_{t-2} - \delta) + \cdots + \alpha_p(Y_{t-p} - \delta) + u_t$$

Moving Average (MA) Process (22.2.4)

$$Y_t = \mu + \beta_0 u_t + \beta_1 u_{t-1}$$

Autoregressive and Moving Average (ARMA) Process (22.2.4)

$$Y_t = \theta + \alpha_1 Y_{t-1} + \beta_0 u_t + \beta_1 u_{t-1}$$

The Box–Jenkins (BJ) Methodology

Step 1: Identification

```
options(scipen = 999)

library(gujarati)

library(dynlm)

library(vars)

library(fGarch)

library(quantmod)

library(scales)

library(forecast)

ggAcf(fredgraph$GDP,24,demean = TRUE)


ggtaperedacf(fredgraph$GDP,
  lag.max = 24,
  type = c("correlation", "partial"),
  plot = TRUE,
  calc.ci = TRUE,
  level = 95
)

ggAcf(fredgraph$GDP,24,type = "partial")
```

Simulation : FIGURE 22.4

This code belongs to Hüseyin Taştan:https://github.com/htastan

```
library(ggplot2)

n <- 1000
set.seed(123)
MD1 <- ts(rnorm(n,0,1))
autoplot(MD1)

ggAcf(MD1)




MDL <- stats::lag(MD1, -1)
x = MD1 + 0.5* MDL
autoplot(x)




set.seed(1234)
# define the lists for the ARIMA(p,d,q) models
# order = c(1, 0, 0) means ARIMA(1,0,0) = AR(1)
# ar is the AR coefficient and sd is the standard deviation
list1 <- list(order = c(1, 0, 0), ar = 0.5, sd = 1)
list2 <- list(order = c(1, 0, 0), ar = 0.8, sd = 1)
list3 <- list(order = c(1, 0, 0), ar = 0.9, sd = 1)
list4 <- list(order = c(1, 0, 0), ar = 0.95, sd = 1)
#
AR1_1 <- arima.sim(n = 500, model = list1)
AR1_2 <- arima.sim(n = 500, model = list2)
AR1_3 <- arima.sim(n = 500, model = list3)
```

```
AR1_4 <- arima.sim(n = 500, model = list4)
#autoplot(AR1_1)


plot1 <- autoplot(AR1_1) + xlab("") + ggtitle("AR(1) = 0.5")
plot2 <- autoplot(AR1_2) + xlab("") + ggtitle("AR(1) = 0.8")
plot3 <- autoplot(AR1_3) + xlab("") + ggtitle("AR(1) = 0.9")
plot4 <- autoplot(AR1_4) + xlab("") + ggtitle("AR(1) = 0.95")
library(grid)
library(gridExtra)
grid.arrange(grobs=list(plot1, plot2, plot3, plot4),
             ncol=2, top="Simulated AR(1) Processes")
```

Step 2 and Step 3 : Estimation of the ARIMA Model Diagnostic Checking

```
MODEL1 = dynlm(log(ts(fredgraph$GDP)) ~  L(log(ts(fredgraph$GDP))))

summary(MODEL1)

MODEL1_1 = dynlm(diff(log(ts(fredgraph$GDP))) ~  L(MODEL1$residuals) +L(MODEL1$residuals,2))

summary(MODEL1_1)

RES1 = MODEL1_1$residuals

ggAcf(RES1,25)
```

Step 4 : Forecasting

```
library(stargazer)

tsdata = ts(fredgraph,start = 1959)

MODEL2 = dynlm(GDP ~  L(GDP),data = tsdata, end = 2008)

MODEL2_1 = dynlm(GDP ~  PCE + L(GDP),data = tsdata, end = 2008)


stargazer(MODEL2, MODEL2_1 ,type="text", keep.stat=c("n","adj.rsq","ser"))



PRED <- predict(MODEL2, newdata=window(tsdata,start=2009), interval="prediction")

PRED2 <- predict(MODEL2_1, newdata=window(tsdata,start=2009), interval="prediction")


gdp <- ts(fredgraph$GDP, start=1959)

AR1 <- ts(PRED, start=2009)

autoplot(gdp) + autolayer(AR1) +geom_point(aes(y=gdp)) +
  geom_vline(xintercept = 2009, linetype=2) +
  ggtitle("GDP Forecasts for 2009-2019 using AR(1) Model")


AR2 = ts(PRED2, start=2009)
autoplot(gdp) + autolayer(AR2) +geom_point(aes(y=gdp)) +
```

```
  geom_vline(xintercept = 2009, linetype=2) +
  ggtitle("GDP Forecasts for 2009-2019 using AR(1) Model")



gdpF <- forecast(fredgraph$GDP, h=30)

plot(gdpF)

y  <- window(tsdata,start=2009)[,"GDP"]
PRED <- predict( MODEL2, newdata=window(tsdata,start=2009) )
PRED1 <- predict( MODEL2_1, newdata=window(tsdata,start=2009) )


matplot(time(y), cbind(y,PRED,PRED1), type="l",  col="black",lwd=2,lty=1:3)
legend("topleft",c("GDP","Forecast 1","Forecast 2"),lwd=2,lty=1:3)
```

Vector Autoregression (VAR)

$$M_{1t} = \alpha + \sum_{j=1}^{k} \beta_j M_{t-j} + \sum_{j=1}^{k} \gamma_j R_{t-j} + u_{1t} \tag{22.9.1}$$

$$R_t = \alpha' + \sum_{j=1}^{k} \theta_j M_{t-j} + \sum_{j=1}^{k} \gamma_j R_{t-j} + u_{2t} \tag{22.9.2}$$

```
fix(Table17_5)

library(fpp2)

date1 = ts(data = 1979:1988, start = c(1979,1), end = c(1988,4), frequency = 4)

date11 <- as.yearqtr(date1, format = "%Y:0%q")

newdata = data.frame(Table17_5,date11)


TGDP <- ts(newdata$GDP,
          start = c(1980, 1),
          end = c(1987, 4),
          frequency = 4)

TM1 <- ts(newdata$M1,
          start = c(1980, 1),
          end = c(1987, 4),
          frequency = 4)

TR <- ts(newdata$R,
          start = c(1980, 1),
          end = c(1987, 4),
          frequency = 4)


VAR_data <- window(ts.union(TM1, TR), start = c(1980, 1), end = c(1987, 4))
```

```
VAR_est <- VAR(y = VAR_data, p = 4,type = "none",ic="AIC")

summary(VAR_est)


forecast(VAR_est) %>%
  autoplot() +
  xlab("year")


causality(VAR_est, cause = "TR")

causality(VAR_est, cause = "TM1")
```