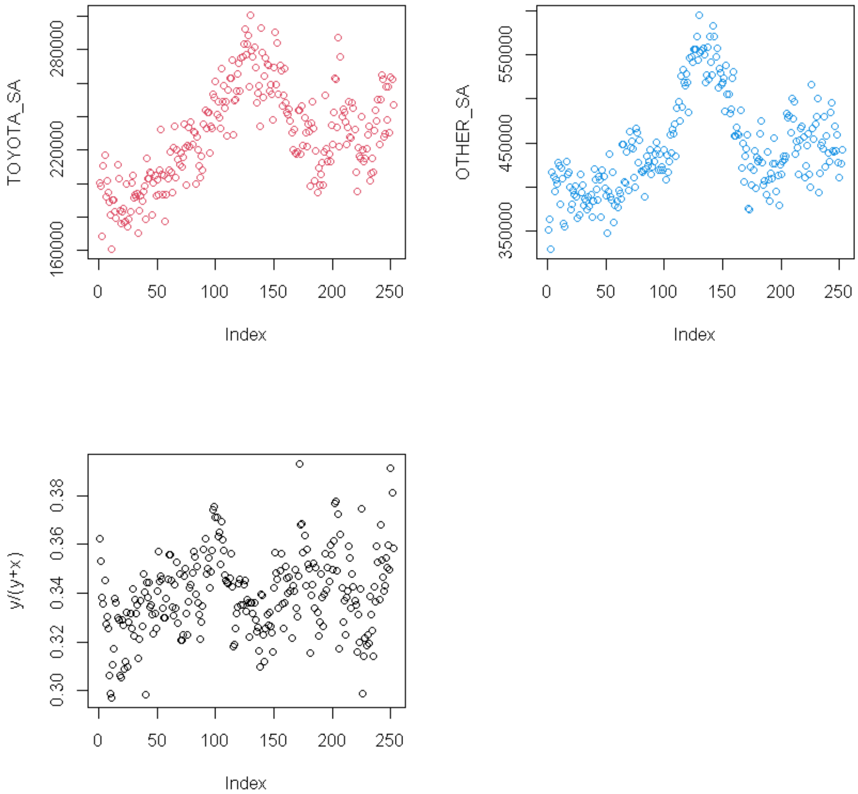
Test Exercise 6

In [152]:
```
data <- read.csv("./data/TestExer6-CARS-round2.csv")
names(data)[1] <- "YEARMONTH"A

n <- nrow(data)

data$T <-c(seq(1, n))
data$YEAR <- substr(data$YEARMONTH, 1, 4)

data$DTOYOTA_SA <- c(NA, diff(data$TOYOTA_SA, lag=1))
data$DOTHER_SA <- c(NA, diff(data$OTHER_SA, lag=1))0
for (i in c(1:12)){
    data[,paste("DTOYOTA_SA_l", i, sep="")] <- c(c(rep(NA, i)), dat
a$DTOYOTA_SA[-((n-i+1):n)])
}
for (i in c(1:3)){
    data[,paste("DOTHER_SA_l", i, sep="")] <- c(c(rep(NA, i)), data
$DOTHER_SA_SA[-((n-i+1):n)])
}

data$TOYOTA_SA_l1 <- c(c(rep(NA, 1)), data$TOYOTA_SA[-((n-0):n)])
data$OTHER_SA_l1 <- c(c(rep(NA, 1)), data$OTHER_SA[-((n-0):n)]))
train <- data[data$YEAR <= 1999,]
test <- data[data$YEAR > 1999,]"
```

Part (a)

y_t and x_t seems to be correlated. $\frac{y_t}{(y_t+x_t)}$ is rather stationary.

In [153]:
```
# attach(mtcars)
par(mfrow=c(2,2))
plot( ata$TOYOTA_SA, ylab="TOYOTA_SA", col=2)
plot(data$OTHER_SA, ylab="OTHER_SA", col=4)
plot(data$TOYOTA_SA /(data$TOYOTA_SA + data$OTHER_SA), ylab="y/(y+x
)")
```



Part (b)

In [154]:
```
TOYOTA_SA_ADF <- lm(DTOYOTA_SA~ TTOYOTA_SA_l1 + DTOYOTA_SA_l1 + DTO
YOTA_SA_l2 + DTOYOTA_SA_l3, data=trin)

sprintf("Formula: DTOYOTA_SA = %.3f - %.3f*TOYOTA_SA_l1* - %.3f*DTO
YOTA_SA_l1* - %.3f*DTOYOTA_SA_l2* - %.3f*DTOYOTA_SA_l3*", coef(TOYO
TA_SA_ADF)[1], -1*coef(TOYOTA_SA_ADF)[2], -1*coef(TOYOTA_SA_ADF)[3]
, -1*coef(TOYOTA_SA_ADF)[4], -1*coef(TOYOTA_SA_ADF)[5])
sprintf("")sprint("LOTOYOTA_SA_l1:")
sprintf("Coefficint = %.5f", summy(LOGTOYOTA_SA_ADF)$coefficient[2,
"Estimate"])
sprintf("td. Error = %.5f", sumy(LOGITOYOTA_SA_ADF)$coefficient[2,
"Std. Error"])
sprintf("t-valu = %.5f > -32.9 Do not rejec LOGIPtTOYOTA_SAis non s
tationary.", y(LOGIPmTOYOTA_SAADF))coefficient[32 "t value"]))
```

'Formula: DTOYOTA_SA = 19281.893 - 0.083*TOYOTA_SA_l1* - 0.563*DTOYOTA_SA_l1* - 0.324*DTOYOTA_SA_l2* - 0.064*DTOYOTA_SA_l3*'

''

'TOYOTA_SA_l1:'

'Coefficient = -0.08322'

'Std. Error = 0.03679'

't-value = -2.26228 > -2.9. Do not reject H0. TOYOTA_SA is non stationary.'

In [155]:
```
OTHER_SA_ADF <- lm(DOTHER_SA ~ OTHER_SA_l1 + DOTHER_SA_l1 + DOTHER_
SA_l2 + DOTHER_SA_l3, data=train)
sprintf("Formula: DOTHER_SA = %.3f - %.3f*OTHER_SA_l1* - %.3f*DOTHE
R_SA_l1* - %.3f*DOTHER_SA_l2* - %.3f*DOTHER_SA_l3*", coef(OTHER_SA_
ADF)[1], -1*coef(OTHER_SA_ADF)[2], -1*coef(OTHER_SA_ADF)[3], -1*coe
f(OTHER_SA_ADF)[4], -1*coef(OTHER_SA_ADF)[5])
sprintf("")
sprintf("OTHER_SA_l1:")
sprintf("Coefficient = %.5f", summary(OTHER_SA_ADF)$coefficient[2,
"Estimate"])
sprintf("Std. Error = %.5f", summary(OTHER_SA_ADF)$coefficient[2, "
Std. Error"])
sprintf("t-value = %.5f > -2.9. Do not reject H0. OTHER_SA is non s
tationary.",summary(OTHER_SA_ADF)$coefficient[2, "t value"])
```

```
Error in lm.fit(x, y, offset = offset, singular.ok = singular.ok,
...): 0 (non-NA) cases
Traceback:

1. lm(DOTHER_SA ~ OTHER_SA_l1 + DOTHER_SA_l1 + DOTHER_SA_l2 + DOTH
ER_SA_l3,
 .     data = train)
2. lm.fit(x, y, offset = offset, singular.ok = singular.ok, ...)
3. stop("0 (non-NA) cases")
```

Part (c)

In [156]:
```
eg <- lm(TOYOTA_SA ~ OTHER_SA, data=train)
sprintf("Formula: *TOYOTA_SA* = %.2f + %.2f*OTHER_SA*", coef(eg)[1]
, coef(eg)[2])
```

'Formula: *TOYOTA_SA* = 26786.41 + 0.45*OTHER_SA*'

In [157]:
```
res_data <- train
res_data$e <- summary(eg)$residuals
res_data$De <- c(NA, diff(res_data$e, lag=1))

n <- nrow(res_data)
res_data$e_l1 <- c(c(rep(NA, 1)), res_data$e[-((n-0):n)])
res_data$De_l1 <- c(c(rep(NA, 1)), res_data$De[-((n-0):n)])
res_data$De_l2 <- c(c(rep(NA, 2)), res_data$De[-((n-1):n)])
res_data$De_l3 <- c(c(rep(NA, 3)), res_data$De[-((n-2):n)])
```

In [158]:
```
res_fit <- lm(De ~ e_l1 + De_l1 + De_l2 + De_l3, data=res_data)
sprintf("Formula: De = %.3f - %.3f*e_l1* - %.3f*De_l1* - %.3f*De_l2
* - %.3f*De_l3*", coef(res_fit)[1], -1*coef(res_fit)[2], -1*coef(re
s_fit)[3], -1*coef(res_fit)[4], -1*coef(res_fit)[5])
sprintf("t-value = %.5f < -3.4. Reject H0. TOYOTA_SA and OTHER_SA a
re cointegrated.", summary(res_fit)$coefficient[3, "t value"])
```

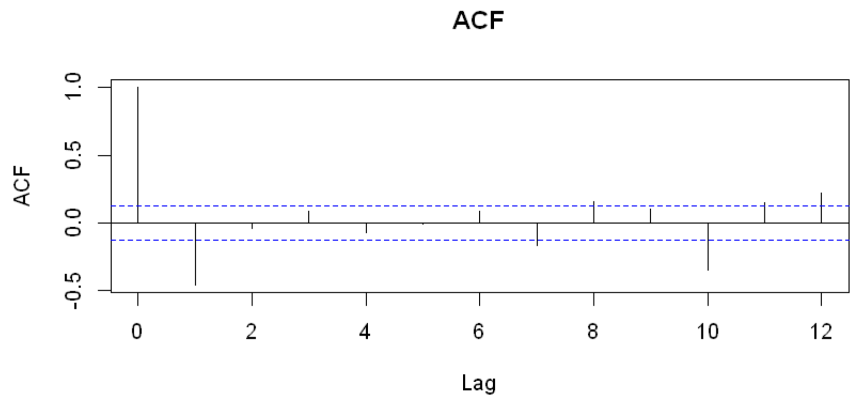
'Formula: De = 24.992 - 0.293*e_l1* - 0.286*De_l1* - 0.142*De_l2* - 0.096*De_l3*'

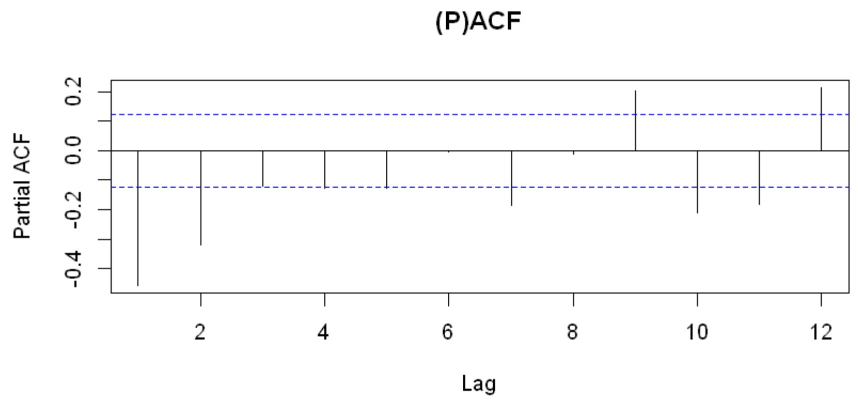
't-value = -3.63959 < -3.4. Reject H0. TOYOTA_SA and OTHER_SA are cointegrated.'

Part (d)

From the graph and OLS, only lags 1 to 5, 10 and 12 are significant.

In [159]:
```
par(mfrow=c(2,1))
acf(na.omit(data$DTOYOTA_SA), lag.max=12, main="ACF")
pacf(na.omit(data$DTOYOTA_SA), lag.max=12, main="(P)ACF")
```





In [160]:
```
evaluate <- lm(DTOYOTA_SA ~ DTOYOTA_SA_l1 + DTOYOTA_SA_l2 + DTOYOTA
_SA_l3 + DTOYOTA_SA_l4 + DTOYOTA_SA_l5 + DTOYOTA_SA_l6 + DTOYOTA_SA
_l7 + DTOYOTA_SA_l8 + DTOYOTA_SA_l9 + DTOYOTA_SA_l10 + DTOYOTA_SA_l
11 + DTOYOTA_SA_l12, data=train)
```

In [161]:
```
summary(evaluate)
```

```
Call:
lm(formula = DTOYOTA_SA ~ DTOYOTA_SA_l1 + DTOYOTA_SA_l2 + DTOYOTA_
SA_l3 +
    DTOYOTA_SA_l4 + DTOYOTA_SA_l5 + DTOYOTA_SA_l6 + DTOYOTA_SA_l7
+
    DTOYOTA_SA_l8 + DTOYOTA_SA_l9 + DTOYOTA_SA_l10 + DTOYOTA_SA_l1
1 +
    DTOYOTA_SA_l12, data = train)

Residuals:
   Min     1Q Median     3Q    Max
-40387  -9196   -402   8322  33993

Coefficients:
                Estimate Std. Error t value Pr(>|t|)
(Intercept)    619.04050  915.32772   0.676 0.499577
DTOYOTA_SA_l1   -0.61619    0.06668  -9.241  < 2e-16 ***
DTOYOTA_SA_l2   -0.30230    0.07886  -3.833 0.000166 ***
DTOYOTA_SA_l3   -0.25794    0.07931  -3.252 0.001331 **
DTOYOTA_SA_l4   -0.26978    0.08119  -3.323 0.001049 **
DTOYOTA_SA_l5   -0.23153    0.08357  -2.770 0.006091 **
DTOYOTA_SA_l6   -0.12142    0.08446  -1.438 0.152006
DTOYOTA_SA_l7   -0.13116    0.08437  -1.555 0.121516
DTOYOTA_SA_l8    0.04496    0.08331   0.540 0.589974
DTOYOTA_SA_l9    0.03573    0.08186   0.437 0.662905
DTOYOTA_SA_l10  -0.26465    0.07981  -3.316 0.001073 **
DTOYOTA_SA_l11  -0.04327    0.07877  -0.549 0.583349
DTOYOTA_SA_l12   0.21971    0.06624   3.317 0.001070 **
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Residual standard error: 13740 on 214 degrees of freedom
  (13 observations deleted due to missingness)
Multiple R-squared:  0.4642,    Adjusted R-squared:  0.4342
F-statistic: 15.45 on 12 and 214 DF,  p-value: < 2.2e-16
```

In [162]:

```
fit <- lm(DTOYOTA_SA ~ DTOYOTA_SA_l1 + DTOYOTA_SA_l2 + DTOYOTA_SA_l
3 + DTOYOTA_SA_l4 + DTOYOTA_SA_l5 + DTOYOTA_SA_l10 + DTOYOTA_SA_l12
, data=train)
sprintf("Formula:")
sprintf("Dyt = %.3f - %.3f*Dyt_l1* - %.3f*Dyt_l2* - %.3f*Dyt_l3* -
%.3f*Dyt_l4* - %.3f*Dyt_l5* - %.3f*Dyt_l10* + %.3f*Dyt_l12*", coef(
fit)[1], -1*coef(fit)[2], -1*coef(fit)[3], -1*coef(fit)[4], -1*coef
(fit)[5], -1*coef(fit)[6], -1*coef(fit)[7], coef(fit)[8])
```

'Formula:'

'Dyt = 561.613 - 0.598*Dyt_l1* - 0.263*Dyt_l2* - 0.227*Dyt_l3* - 0.230*Dyt_l4* - 0.152*Dyt_l5* - 0.268*Dyt_l10* + 0.246*Dyt_l12*'

Part (e)

In [163]:

```
new_data <- data
new_data$EQ <- new_data$TOYOTA_SA_l1 - coef(eg)[2]*new_data$OTHER_S
A_l1

new_train <- new_data[new_data$YEAR <= 1999,]
new_test <- new_data[new_data$YEAR > 1999,]
```

In [164]:

```
ECM_fit <- lm(DTOYOTA_SA ~ EQ + DTOYOTA_SA_l1 + DTOYOTA_SA_l2 + DTO
YOTA_SA_l3 + DTOYOTA_SA_l4 + DTOYOTA_SA_l5 + DTOYOTA_SA_l10 + DTOYO
TA_SA_l12, data=new_train)
sprintf("Formula:")
sprintf("Dyt = %.3f - %.3f(*yt_l1* - 0.45*xt_l1*) - %.3f*Dyt_l1* -
%.3f*Dyt_l2* - %.3f*Dyt_l3* - %.3f*Dyt_l4* - %.3f*Dyt_l5* - %.3f*Dy
t_l10* + %.3f*Dyt_l12*", coef(ECM_fit)[1], -1*coef(ECM_fit)[2], -1*
coef(ECM_fit)[3], -1*coef(ECM_fit)[4], -1*coef(ECM_fit)[5], -1*coef
(ECM_fit)[6], -1*coef(ECM_fit)[7], coef(ECM_fit)[8], coef(ECM_fit)[
9])
```

'Formula:'

'Dyt = 4602.114 - 0.150(*yt_l1* - 0.45*xt_l1*) - 0.523*Dyt_l1* - 0.187*Dyt_l2* - 0.158*Dyt_l3* - 0.185*Dyt_l4* - 0.133*Dyt_l5* - -0.274*Dyt_l10* + 0.252*Dyt_l12*'

In [165]:
```
rsq_0 <- as.numeric(summary(fit)$r.squared)
rsq_1 <- as.numeric(summary(ECM_fit)$r.squared)
n <- nrow(na.omit(train))
g <- 1 #no. of excluded variables
k <- 9 #total number of variables in unrestricted model
F5 <- (rsq_1 - rsq_0) * (n - k) / (1 - rsq_1) / g

sprintf("Critical value at 5%% level=%.3f", qf(.95, df1=g, df2=n-k)
)
sprintf("Critical value at 1%% level=%.3f", qf(.99, df1=g, df2=n-k)
)

sprintf("F = %.3f > 3.9, therefore reject H0 at 5%% level", F)
sprintf("F = %.3f < 6.8, therefore do not reject H0 at 1%% level",
F)
```

```
Warning message in qf(0.95, df1 = g, df2 = n - k):
"NaNs produced"
```

'Critical value at 5% level=NaN'

```
Warning message in qf(0.99, df1 = g, df2 = n - k):
"NaNs produced"
```

'Critical value at 1% level=NaN'

'F = 4.630 > 3.9, therefore reject H0 at 5% level'

'F = 4.630 < 6.8, therefore do not reject H0 at 1% level'

Part (f)

In [166]:
```
result <- test[,c("YEAR","DTOYOTA_SA")]
```

In [167]:
```
result$AR <- predict(fit, newdata=new_test)
result$ECM <- predict(ECM_fit, newdata=new_test)
```

In [168]:
```
result_error <- result
result_error$AR <- result_error$DTOYOTA_SA - result_error$AR
result_error$ECM <- result_error$DTOYOTA_SA - result_error$ECM
```

In [169]:
```
n <- nrow(result_error)

for (col in c("AR", "ECM")){
    values <- result_error[, col]
    print(col)
    print(eval(sprintf("RMSE = %.5f", sqrt(1/n*sum(values**2)))))
    print(eval(sprintf("MAE = %.5f", 1/n*sum(abs(values)))))
    print("")
}
```

```
[1] "AR"
[1] "RMSE = 16991.79876"
[1] "MAE = 14703.21887"
[1] ""
[1] "ECM"
[1] "RMSE = 18202.60915"
[1] "MAE = 15552.91652"
[1] ""
```

AR model (without the Error Correction) does better in the out-of-sample set with lower RMSE and MAE.

In [ ]:

In [ ]: