Exercises 9.25

Import data

First, Set the environment and import data. *Note that i wrote the code using R*

```
rm(list=ls())
library(dplyr) #dataframe management
library(haven) #library for importing data set
library(psych) #library for trace matrix
invest <- read_dta("Invest1993.dta")
invest <- invest %>%
  select(year,inva,vala,cfa,debta) %>%
  rename(I = inva, Q = vala, C= cfa, D=debta)
```

Table 1: First 10 elements of Invest1993

year	I	Q	C	D
1970	0.12219	1.17240	0.20030	0.04644
1971	0.09184	0.79165	0.07234	0.66158
1972	0.09390	0.91267	0.22845	0.57597
1973	0.11600	0.28577	0.24793	0.51771
1974	0.09858	0.29713	0.25247	0.54761
1975	0.18723	0.55619	0.33465	0.34432
1976	0.34948	0.38053	0.24269	0.55432
1977	0.18235	0.56665	0.11990	0.60564
1987	0.09453	9.06242	3.26980	8.74559
1988	0.04377	16.89927	5.01435	5.99452

```
invest %>%
  group_by(year) %>%
  summarise(mean(I),mean(Q),mean(C),mean(D))
```

```
## # A tibble: 32 x 5
##     year `mean(I)` `mean(Q)` `mean(C)` `mean(D)`
##    <dbl>     <dbl>     <dbl>     <dbl>     <dbl>
##  1  1960    0.101      0.856     0.178     0.224
##  2  1961    0.0856     1.45      0.203     0.218
##  3  1962    0.101      1.07      0.213     0.230
##  4  1963    0.0852     1.34      0.213     0.224
##  5  1964    0.0925     1.47      0.232     0.229
##  6  1965    0.104      1.72      0.245     0.250
##  7  1966    0.111      1.43      0.248     0.267
##  8  1967    0.103      2.03      0.233     0.287
##  9  1968    0.100      2.25      0.240     0.275
## 10  1969    0.105      1.72      0.218     0.274
## # ... with 22 more rows
```

(a) Extract the sub-sample of observations for 1987. There should be 1028 observations. Estimate a linear regression of I (investment to capital ratio) on the other variables. Calculate

appropriate standard errors.

```
sub_inv <- invest %>%
  filter(year == 1987)
sub_inv %>%
  count()
```

```
## # A tibble: 1 x 1
##       n
##   <int>
## 1  1028
```

Table 2: First 10 elements of subset

year	I	Q	C	D
1987	0.09453	9.06242	3.26980	8.74559
1987	0.21791	3.93320	0.93207	0.08036
1987	0.12129	0.64275	0.14233	0.29322
1987	0.17749	0.66007	0.15122	0.33150
1987	0.14425	0.82322	0.31672	0.00000
1987	0.16338	0.16403	0.13421	0.95552
1987	0.03948	0.52889	0.11523	0.56233
1987	0.09754	2.53279	0.67836	0.00000
1987	0.32648	0.64949	0.16219	0.66059
1987	0.14810	3.74803	0.57099	0.12111

Lets set the regression equation for estimation.

$$I = \beta_1 Q + \beta_2 C + \beta_3 D + \beta_4$$

Calculation of linear regression estimate is following codes.

```
X <- sub_inv %>%
  select(-year) %>%
  select(-I) %>%
  bind_cols(data.frame(con=rep(1,nrow(sub_inv))))
X <- as.matrix(X)
Y <- sub_inv %>%
  select(I)
Y <- as.matrix(Y)

beta_hat <- solve((t(X) %*% X)) %*% (t(X) %*% Y)
e_hat <- Y - X %*% beta_hat

XX <- solve((t(X) %*% X)) #XX is variable name it means inverse matrix of (X'X)
leverage <- diag(X%*%XX%*%t(X))

u3 <- X * ((e_hat/(1-leverage))%*% matrix(1,1,ncol(X)))
v3 <- XX %*% (t(u3) %*% u3) %*% XX
s3 <- sqrt(diag(v3))
```

Table 3: Coefficient estimates and Robust S.E.

	Coefficient	Robust standard errors
Q	0.0027674	0.0017771
C	0.0044900	0.0234292
D	0.0123349	0.0071883
Constant	0.1007802	0.0073585

Thus estimated equation is

$$\hat{I} = \underset{(0.001777149).}{0.002767410Q} + \underset{(0.023429188)}{0.004489979C} + \underset{(0.007188266)}{0.012334930D} + \underset{(0.007358536)***}{0.100780183}$$

Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

(b) Calculate asymptotic confidence intervals for the coefficients.

Following codes are calculation of 95% CI for coefficients.Basically method of calculation is same with exercise 7.28.

```
#CI for Beta_1 hat
beta_hat['Q',]+1.96*sqrt(v3['Q','Q'])
beta_hat['Q',]-1.96*sqrt(v3['Q','Q'])

#CI for Beta_2 hat
beta_hat['C',]+1.96*sqrt(v3['C','C'])
beta_hat['C',]-1.96*sqrt(v3['C','C'])

#CI for Beta_3 hat
beta_hat['D',]+1.96*sqrt(v3['D','D'])
beta_hat['D',]-1.96*sqrt(v3['D','D'])

#CI for Beta_4 hat
beta_hat['con',]+1.96*sqrt(v3['con','con'])
beta_hat['con',]-1.96*sqrt(v3['con','con'])
```

$$\begin{aligned}
CI_{\hat{\beta}_1} &= [-0.000715802, 0.006250621] \\
CI_{\hat{\beta}_2} &= [-0.04143123, 0.05041119] \\
CI_{\hat{\beta}_3} &= [-0.001754072, 0.02642393] \\
CI_{\hat{\beta}_4} &= [0.08635745, 0.1152029]
\end{aligned}$$

(c) This regression is related to Tobin's q theory of investment, which suggests that investment should be predicted solely by Q (Tobin's Q). This theory predicts that the coefficient on Q should be positive and the others should be zero. Test the joint hypothesis that the coefficients on cash flow (C) and debt (D) are zero. Test the hypothesis that the coefficient on Q is zero.

Are the results consistent with the predictions of the theory?

Test the joint hypothesis that the coefficients on cash flow (C) and debt (D) are zero.

Construct hypothesis test. Let $\alpha = 0.05$.

$$\mathbb{H}_0 : \beta_2 = 0 \ \& \ \beta_3 = 0$$
$$\mathbb{H}_1 : \beta_2 \neq 0 \ \& \ \beta_3 \neq 0$$

we can rewrite hypothesis as

$$\mathbb{H}_0 : C\beta = 0$$
$$\mathbb{H}_1 : C\beta \neq 0$$

0 is $q \times 1$ vector of zeros.

To test hypothesis, the Wald statistic is

$$W = (C\hat{\beta})'(C\hat{\mathbf{V}}_{\hat{\beta}}C')^{-1}(C\hat{\beta})$$

Calculate Wald statistic:
C matrix is

$$C = \begin{bmatrix} 0 & 1 & 0 & 0 \\ 0 & 0 & 1 & 0 \end{bmatrix}$$

Thus calculation of W is following codes.

```
const <- matrix(0,2,4)
const[1,2] <- 1
const[2,3] <- 1
W <- t(const%*%beta_hat)%*%solve(const%*%v3%*%t(const))%*%(const%*%beta_hat)
```

```
qchisq(0.95,2)
```

```
## [1] 5.991465
```

$W = 2.988674$, Critical values c satisfying $\alpha = 1 - G_q(c)$,$0.05 = 1 - G_2(c)$ thus $c = 5.991465$. Since $W = 2.988674 < c = 5.991465$, We cannot reject $\mathbb{H}_0$.

Test the hypothesis that the coefficient on Q is zero.

Construct hypothesis test. Let $\alpha = 0.05$.

$$\mathbb{H}_0 : \beta_1 = 0$$
$$\mathbb{H}_1 : \beta_1 \neq 0$$

Since t statistic is

$$t(\beta_1) = \frac{\hat{\beta}_1}{s(\hat{\beta}_1)} = \frac{0.002767410}{0.001777149} = 1.557219$$

since $c = 1.96$,$|t(\beta_1)| < c$ thus we cannot reject $\mathbb{H}_0$.

(d) Now try a nonlinear(quadratic) specification. Regress I on $Q, C, D, Q^2, C^2, D^2, Q \times C, Q \times D, C \times D$. Test the joint hypothesis that the six interaction and quadratic coefficients are zero.