Q18

(a)

```
> cat(round(mother_pct, 2), "%\n")
12.15 %
> cat(round(father_pct, 2), "%\n")
11.68 %
```

(b)

```
[1] "educ, mothereduc 與 fathereduc 的相關係數矩陣："
> print(cor_matrix)
                educ mothercoll fathercoll
educ       1.0000000  0.3594705  0.3984962
mothercoll 0.3594705  1.0000000  0.3545709
fathercoll 0.3984962  0.3545709  1.0000000
>
```

EDUC 和 MOTHERCOLL 之間的相關係數為 0.3595，而 EDUC 和 FATHERCOLL 之間的相關係數為 0.3985，顯示曾經上過大學的父母，對於子女教育的重視程度會高於那些沒有上過大學的父母。

(c)

```
educ        -0.001219763  1.532557e-01
```

(d)

```
Residuals:
    Min      1Q  Median      3Q     Max 
-7.4267 -0.4826 -0.3731  1.0000  4.9353 

Coefficients:
             Estimate Std. Error t value Pr(>|t|)    
(Intercept) 12.079094   0.303118  39.849  < 2e-16 ***
mothercoll   2.517068   0.315713   7.973 1.46e-14 ***
exper        0.056230   0.042101   1.336    0.182    
exper2      -0.001956   0.001256  -1.557    0.120    
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Residual standard error: 2.133 on 424 degrees of freedom
Multiple R-squared:  0.1347,	Adjusted R-squared:  0.1285 
F-statistic: 21.99 on 3 and 424 DF,  p-value: 2.965e-13


Linear hypothesis test:
mothercoll = 0

Model 1: restricted model
Model 2: educ ~ mothercoll + exper + exper2

  Res.Df    RSS Df Sum of Sq      F    Pr(>F)    
1    425 2219.2                                  
2    424 1929.9  1    289.32 63.563 1.455e-14 ***
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1
```

MOTHERCOLL 的係數的 t 統計量為 7.973，對應的 F 值為 63.563，我們**拒絕**虛無假設 H0，MOTHERCOLL 對 EDUC 有顯著影響，MOTHERCOLL 是一個**強工具變數**。

(e)

```
educ          0.02751845   1.481769e-01
```

信賴區間**略為窄一些**

(f)

```
Residuals:
    Min      1Q  Median      3Q     Max 
-7.2152 -0.3056 -0.2152  0.7627  5.0620 

Coefficients:
             Estimate Std. Error t value Pr(>|t|)    
(Intercept) 11.890259   0.290251  40.965  < 2e-16 ***
mothercoll   1.749947   0.322347   5.429 9.58e-08 ***
fathercoll   2.186612   0.329917   6.628 1.04e-10 ***
exper        0.049149   0.040133   1.225    0.221    
exper2      -0.001449   0.001199  -1.209    0.227    
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Residual standard error: 2.033 on 423 degrees of freedom
Multiple R-squared:  0.2161,	Adjusted R-squared:  0.2086 
F-statistic: 29.15 on 4 and 423 DF,  p-value: < 2.2e-16
```

```
Linear hypothesis test:
mothercoll = 0
fathercoll = 0

Model 1: restricted model
Model 2: educ ~ mothercoll + fathercoll + exper + exper2

  Res.Df    RSS Df Sum of Sq      F    Pr(>F)    
1    425 2219.2                                  
2    423 1748.3  2    470.88 56.963 < 2.2e-16 ***
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

MOTHERCOLL 和 FATHERCOLL 的聯合顯著性的 F 統計量為 56.963，因此拒絕工具變數是弱工具變數的虛無假設。

(g)

```
> (p_value <- 1 - pchisq(S, df = 1))
[1] 0.6281333
```

不拒絕虛無假設，工具變數在回歸模型中沒有問題

Q20

(a)

```
Call:
lm(formula = riskfree_msft ~ riskfree_mkt, data = capm5)

Residuals:
     Min       1Q   Median       3Q      Max 
-0.27424 -0.04744 -0.00820  0.03869  0.35801 

Coefficients:
             Estimate Std. Error t value Pr(>|t|)    
(Intercept)  0.003250   0.006036   0.538    0.591    
riskfree_mkt 1.201840   0.122152   9.839   <2e-16 ***
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Residual standard error: 0.08083 on 178 degrees of freedom
Multiple R-squared:  0.3523,	Adjusted R-squared:  0.3486 
F-statistic:  96.8 on 1 and 178 DF,  p-value: < 2.2e-16
```

B=1.20184，相較於市場投資組合 Microsoft 股票風險較高

(b)

```
Call:
lm(formula = riskfree_mkt ~ RANK, data = capm5)

Residuals:
      Min        1Q    Median        3Q       Max 
-0.110497 -0.006308  0.001497  0.009433  0.029513 

Coefficients:
              Estimate Std. Error t value Pr(>|t|)    
(Intercept) -7.903e-02  2.195e-03   -36.0   <2e-16 ***
RANK         9.067e-04  2.104e-05    43.1   <2e-16 ***
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Residual standard error: 0.01467 on 178 degrees of freedom
Multiple R-squared:  0.9126,	Adjusted R-squared:  0.9121 
F-statistic:  1858 on 1 and 178 DF,  p-value: < 2.2e-16
```

R^2=0.9126。

t 值為 43.1，F 統計量為 1858，這表示 RANK 是一個非常強的工具變數

(c)

```
Call:
lm(formula = riskfree_msft ~ riskfree_mkt + what, data = capm5)

Residuals:
     Min       1Q   Median       3Q      Max 
-0.27140 -0.04213 -0.00911  0.03423  0.34887 

Coefficients:
              Estimate Std. Error t value Pr(>|t|)    
(Intercept)   0.003018   0.005984   0.504   0.6146    
riskfree_mkt  1.278318   0.126749  10.085   <2e-16 ***
what         -0.874599   0.428626  -2.040   0.0428 *  
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Residual standard error: 0.08012 on 177 degrees of freedom
Multiple R-squared:  0.3672,	Adjusted R-squared:   0.36 
F-statistic: 51.34 on 2 and 177 DF,  p-value: < 2.2e-16
```

t 統計量為−2.04，p 值為 0.0428，在 1%顯著水準下並不顯著，但在 5%水準下是顯著的，在 1%顯著水準下，不拒絕市場報酬為外生變數的虛無假設。

(d)

```
Call:
ivreg(formula = riskfree_msft ~ riskfree_mkt | RANK, data = capm5)

Residuals:
      Min        1Q    Median        3Q       Max 
-0.271625 -0.049675 -0.009693  0.037683  0.355579 

Coefficients:
             Estimate Std. Error t value Pr(>|t|)    
(Intercept)  0.003018   0.006044   0.499    0.618    
riskfree_mkt 1.278318   0.128011   9.986   <2e-16 ***
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Residual standard error: 0.08092 on 178 degrees of freedom
Multiple R-Squared: 0.3508,	Adjusted R-squared: 0.3472 
Wald test: 99.72 on 1 and 178 DF,  p-value: < 2.2e-16
```

Microsoft β 的 IV（工具變數）估計值為 1.2783，略高於 OLS 估計值 1.2018，因為 OLS 可能因市場超額報酬的測量誤差而產生衰減偏誤。

(e)

```
Call:
lm(formula = riskfree_mkt ~ RANK + POS, data = capm5)

Residuals:
      Min        1Q    Median        3Q       Max 
-0.109182 -0.006732  0.002858  0.008936  0.026652 

Coefficients:
              Estimate Std. Error t value Pr(>|t|)    
(Intercept) -0.0804216  0.0022622  -35.55   <2e-16 ***
RANK         0.0009819  0.0000400   24.55   <2e-16 ***
POS         -0.0092762  0.0042156   -2.20   0.0291 *  
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Residual standard error: 0.01451 on 177 degrees of freedom
Multiple R-squared:  0.9149,	Adjusted R-squared:  0.9139 
F-statistic: 951.3 on 2 and 177 DF,  p-value: < 2.2e-16
```

```
Linear hypothesis test:
RANK = 0
POS = 0

Model 1: restricted model
Model 2: riskfree_mkt ~ RANK + POS

  Res.Df     RSS Df Sum of Sq      F    Pr(>F)    
1    179 0.43784                                  
2    177 0.03727  2   0.40057 951.26 < 2.2e-16 ***
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1
```

F 檢定統計量為 951.3，表示 RANK 和 POS 在統計上聯合顯著不為零，拒絕虛無假設（RANK 和 POS 的係數皆為 0）。

(f)

```
lm(formula = riskfree_msft ~ riskfree_mkt + u_iv, data = capm5)

Residuals:
     Min       1Q   Median       3Q      Max 
-0.27132 -0.04261 -0.00812  0.03343  0.34867 

Coefficients:
              Estimate Std. Error t value Pr(>|t|)    
(Intercept)   0.003004   0.005972   0.503   0.6157    
riskfree_mkt  1.283118   0.126344  10.156   <2e-16 ***
u_iv         -0.954918   0.433062  -2.205   0.0287 *  
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Residual standard error: 0.07996 on 177 degrees of freedom
Multiple R-squared:  0.3696,	Adjusted R-squared:  0.3625 
F-statistic: 51.88 on 2 and 177 DF,  p-value: < 2.2e-16
```

殘差的 t 值為−2.205，p 值為 0.0287，在 1%顯著水準下，不拒絕虛無假設(市場報酬為外生變數)。

(g)

```
Call:
ivreg(formula = riskfree_msft ~ riskfree_mkt | RANK + POS, data = capm5)

Residuals:
     Min       1Q   Median       3Q      Max 
-0.27168 -0.04960 -0.00983  0.03762  0.35543 

Coefficients:
             Estimate Std. Error t value Pr(>|t|)    
(Intercept)  0.003004   0.006044   0.497     0.62    
riskfree_mkt 1.283118   0.127866  10.035   <2e-16 ***
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Residual standard error: 0.08093 on 178 degrees of freedom
Multiple R-Squared: 0.3507,	Adjusted R-squared: 0.347 
Wald test: 100.7 on 1 and 178 DF,  p-value: < 2.2e-16
```

係數估計值 1.28> OLS 估計值，如果存在測量誤差問題，OLS 估計量會受到衰減偏誤的影響，其估計值會向下偏誤。

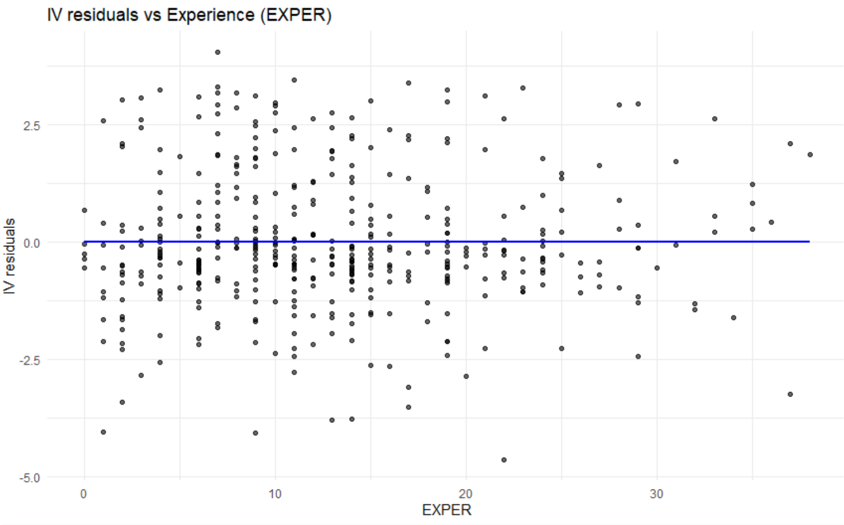
(h)

```
> cat("Sargan 統計量 =", round(sargan_stat, 3), ", p 值 =", round(pval, 4), "\n")
Sargan 統計量 = 0.558 , p 值 = 0.4549
```

在 5%的顯著水準下，不拒絕虛無假設(RANK 和 POS 作為工具變數有效性的證據)，這表示它們可以被視為模型中的外生變數。

Q24

(a)



這張圖的殘差分布未顯示異質變異（heteroskedasticity）的明顯模式，因此圖形上支持同質變異性

(b)

```
> # 顯示結果
> cat("nR² =", round(nR2, 4), ", p-value =", round(pval, 6), "\n")
nR² = 7.4386 , p-value = 0.006384
```

拒絕虛無假設 (誤差變異數為常數)

(c)

```
             Estimate  Std. Error t value Pr(>|t|)
(Intercept)  0.04810030 0.42979772  0.1119 0.910945
educ         0.06139663 0.03333859  1.8416 0.066231 .
exper        0.04417039 0.01554638  2.8412 0.004711 **
I(exper^2)  -0.00089897 0.00043008 -2.0902 0.037193 *
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

>
> # 教育年數的 95% CI，用 robust SE 計算
> coef_educ <- coef(iv_model)["educ"]
> se_educ <- robust_se["educ"]
>
> lower <- coef_educ - 1.96 * se_educ
> upper <- coef_educ + 1.96 * se_educ
> cat("Robust 95% CI for EDUC: [", round(lower, 4), ",", round(upper, 4), "]\n")
Robust 95% CI for EDUC: [ -0.0039 , 0.1267 ]
>
```

(d)

```
[1] -0.002000496  0.124793752
```

Bootstrap 標準誤略微小於穩健標準誤，但仍然比一般的 IV 標準誤（usual IV standard errors）稍大一些。