Q 28 a

需求 $Q_i = \alpha_1 + \alpha_2 P_i + \alpha_3 PS_i + \alpha_4 DI_i + e_{di}$

供給 $Q_i = \beta_1 + \beta_2 P_i + \beta_3 PF_i + e_{si}$

需求 $\alpha_2 P_i = Q_i - \alpha_1 - \alpha_3 PS_i - \alpha_4 DI_i - e_{di}$

⇒

供給 $\beta_2 P_i = Q_i - \beta_1 - \beta_3 PF_i - e_{si}$

⇒ 需求 $P_i = \frac{Q_i}{\alpha_2} - \frac{\alpha_1}{\alpha_2} - \frac{\alpha_3 PS_i}{\alpha_2} - \frac{\alpha_4 DI_i}{\alpha_2} - \frac{e_{di}}{\alpha_2}$

供給 $P_i = \frac{Q_i}{\beta_2} - \frac{\beta_1}{\beta_2} - \frac{\beta_3 PF_i}{\beta_2} - \frac{e_{si}}{\beta_2}$

需求 $\frac{1}{\alpha_2} < 0$ $-\frac{\alpha_3}{\alpha_2} > 0$ $\frac{-\alpha_4}{\alpha_2} > 0$

供給 $\frac{1}{\beta_2} > 0$ $-\frac{\beta_3}{\beta_2} > 0$

(b)

需求

```
Residuals:
    Min      1Q  Median      3Q     Max
-39.661  -6.781   2.410   8.320  20.251

Coefficients:
            Estimate Std. Error t value Pr(>|t|)
(Intercept)  -11.428     13.592  -0.841  0.40810
q             -2.671      1.175  -2.273  0.03154 *
ps             3.461      1.116   3.103  0.00458 **
di            13.390      2.747   4.875 4.68e-05 ***
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Residual standard error: 13.17 on 26 degrees of freedom
Multiple R-Squared: 0.5567,     Adjusted R-squared: 0.5056
Wald test: 17.37 on 3 and 26 DF,  p-value: 2.137e-06
```

供給

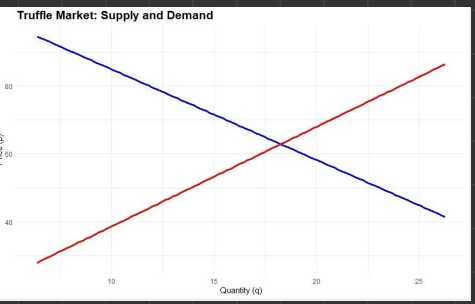
```
Residuals:
    Min      1Q  Median      3Q     Max
-9.7983 -2.3440 -0.6281  2.4350 11.1600

Coefficients:
            Estimate Std. Error t value Pr(>|t|)
(Intercept) -58.7982     5.8592  -10.04 1.32e-10 ***
q             2.9367     0.2158   13.61 1.32e-13 ***
pf            2.9585     0.1560   18.97  < 2e-16 ***
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Residual standard error: 4.399 on 27 degrees of freedom
Multiple R-Squared: 0.9486,     Adjusted R-squared: 0.9448
Wald test: 232.7 on 2 and 27 DF,  p-value: < 2.2e-16
```

係數符號皆正確

(c)

```
> # 計算彈性
> ed <- (1 / delta_2) * (mean_p / mean_q)
> cat("需求的平均點價格彈性為：", round(ed, 3), "\n")
需求的平均點價格彈性為： -1.272
```

(d)



(e)

```
> cat("均衡數量 q* =", round(q_eq, 3), "\n")
均衡數量 q* = 18.25
> cat("均衡價格 p* =", round(p_eq, 3), "\n")
均衡價格 p* = 62.843
```

```
> p_hat <- c + b_ps * ps_star + b_di * di_star + b_pf * pf_star
> cat("Reduced-form 預測價格 P* =", round(p_hat, 3), "\n")
Reduced-form 預測價格 P* = 62.814
>
>
> # 預測 Q
> q_hat <- c_q + bq_ps * ps_star + bq_di * di_star + bq_pf * pf_star
> cat("Reduced-form 預測數量 Q* =", round(q_hat, 3), "\n")
Reduced-form 預測數量 Q* = 18.26
```

預測結果相當一致

(f)

```
# A tibble: 14 x 6
   model       term         estimate std.error statistic  p.value
   <chr>       <chr>           <dbl>     <dbl>     <dbl>    <dbl>
 1 Demand 2SLS (Intercept)  -11.4       13.6      -0.841 4.08e- 1
 2 Demand 2SLS q              -2.67      1.17     -2.27  3.15e- 2
 3 Demand 2SLS ps              3.46      1.12      3.10  4.58e- 3
 4 Demand 2SLS di             13.4       2.75      4.87  4.68e- 5
 5 Demand OLS  (Intercept)  -13.6       9.09      -1.50  1.46e- 1
 6 Demand OLS  q              0.151     0.499      0.303 7.64e- 1
 7 Demand OLS  ps             1.36      0.594      2.29  3.03e- 2
 8 Demand OLS  di            12.4       1.83       6.77  3.48e- 7
 9 Supply 2SLS (Intercept)  -58.8       5.86     -10.0   1.32e-10
10 Supply 2SLS q              2.94      0.216     13.6   1.32e-13
11 Supply 2SLS pf             2.96      0.156     19.0   3.88e-17
12 Supply OLS  (Intercept)  -52.9       5.02     -10.5   4.68e-11
13 Supply OLS  q              2.66      0.171     15.5   5.42e-15
14 Supply OLS  pf             2.92      0.148     19.7   1.47e-17
>
> # 如需寫入 csv：
> # write.csv(all_results, "regression_comparison_results.csv", row.names = FALSE)
```

OLS 的需求函數 q 的符號錯誤且不顯著

其餘的符號正確且顯著

CH 11-30

(a)

```
Residuals:
     Min       1Q   Median       3Q      Max
-2.56562 -0.63169  0.03687  0.41542  1.49226

Coefficients:
             Estimate Std. Error t value Pr(>|t|)
(Intercept) 10.12579    5.46555   1.853 0.081374 .
p            0.47964    0.09711   4.939 0.000125 ***
plag         0.33304    0.10086   3.302 0.004212 **
klag        -0.11179    0.02673  -4.183 0.000624 ***
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1
```

a. 當期利潤（p）和一期前利潤（plag）都具有正向係數：當企業賺取較高利潤並擁有充足的內部資金時，會增加其投資支出，這與預期中「利潤越高、投資越多」的正向利潤 - 投資關係一致。相對地，對於一期前資本存量（klag），其係數為負：即現有資本基礎越大，企業對新增資本的邊際需求越低，這與加速器模型（accelerator model）的預測一致。

三個主要斜率係數在 1% 至 5% 顯著水準下皆與零有統計上顯著差異。

(b)

```
Residuals:
    Min      1Q  Median      3Q     Max
-3.9067 -1.3050  0.3226  1.3613  2.8881

Coefficients:
             Estimate Std. Error t value Pr(>|t|)
(Intercept) 50.38442   31.63026   1.593   0.1352
g            0.43902    0.39114   1.122   0.2820
w2          -0.07961    2.53382  -0.031   0.9754
tx          -0.92310    0.43376  -2.128   0.0530 .
plag         0.80250    0.51886   1.547   0.1459
klag        -0.21610    0.11911  -1.814   0.0928 .
time         0.31941    0.77813   0.410   0.6881
elag         0.02200    0.28216   0.078   0.9390
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1
```

```
  Res.Df    RSS Df Sum of Sq      F Pr(>F)
1     18 108.04
2     13  61.95  5    46.093 1.9345 0.1566
```

F = 1.93 p = 0.1566

不具有共同的統計顯著性

```
2   12.4 13.255556 -0.8555556
3   16.9 16.577368  0.3226319
4   18.4 19.282347 -0.8823465
5   19.4 20.960143 -1.5601433
6   20.1 19.766509  0.3334910
7   19.6 18.238731  1.3612688
8   19.8 17.573065  2.2269354
9   21.1 19.541720  1.5582796
10  21.7 20.375101  1.3248995
11  15.6 17.180415 -1.5804148
12  11.4 12.705026 -1.3050261
13   7.0  8.999780 -1.9997802
14  11.2  9.054102  2.1458976
15  12.3 12.671263 -0.3712632
16  14.0 14.421338 -0.4213385
17  17.6 14.711907  2.8880932
18  17.3 19.796405 -2.4964049
19  15.3 19.206691 -3.9066913
20  19.0 17.419605  1.5803947
21  21.1 20.305654  0.7943462
22  23.5 22.657273  0.8427268
```

(c)

```
Residuals:
     Min       1Q   Median       3Q      Max
-1.04645 -0.56030  0.06189  0.25348  1.36700

Coefficients:
             Estimate Std. Error t value Pr(>|t|)
(Intercept) 20.27821    4.70179   4.313 0.000536 ***
p            0.15022    0.10798   1.391 0.183222
plag         0.61594    0.10147   6.070 1.62e-05 ***
klag        -0.15779    0.02252  -7.007 2.96e-06 ***
vhat         0.57451    0.14261   4.029 0.000972 ***
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Residual standard error: 0.7331 on 16 degrees of freedom
Multiple R-squared:  0.9659,    Adjusted R-squared:  0.9574
F-statistic: 113.4 on 4 and 16 DF,  p-value: 1.588e-11
```

$\hat{v}$ < 0.001 顯著，P是內生的

(d)

```
Residuals:
    Min      1Q  Median      3Q     Max
-3.2909 -0.8069  0.1423  0.8601  1.7956

Coefficients:
            Estimate Std. Error t value Pr(>|t|)
(Intercept) 20.27821    8.38325   2.419  0.02707 *
p            0.15022    0.19253   0.780  0.44598
plag         0.61594    0.18093   3.404  0.00338 **
klag        -0.15779    0.04015  -3.930  0.00108 **
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Residual standard error: 1.307 on 17 degrees of freedom
Multiple R-Squared: 0.8849,     Adjusted R-squared: 0.8646
Wald test:  41.2 on 3 and 17 DF,  p-value: 5.148e-08
```

A tibble: 8 × 6

term	estimate	std.error	statistic	p.value	model
<chr>	<dbl>	<dbl>	<dbl>	<dbl>	<chr>
(Intercept)	10.1	5.47	1.85	0.0814	OLS
p	0.480	0.0971	4.94	0.000125	OLS
plag	0.333	0.101	3.30	0.00421	OLS
klag	-0.112	0.0267	-4.18	0.000624	OLS
(Intercept)	9.82	5.49	1.79	0.0913	2SLS
p	0.489	0.0984	4.97	0.000116	2SLS
plag	0.325	0.102	3.19	0.00538	2SLS
klag	-0.110	0.0268	-4.12	0.000721	2SLS

- **OLS 回歸**的結果顯示，當期利潤 P_t 的係數為 **0.48**，在 1% 顯著水準下是**顯著的**。但這可能反映了**同時性偏誤（simultaneity bias）**：高投資年份通常也會有高利潤，因此會**誤估 P_t 的影響力**，導致斜率被高估。
- **2SLS 回歸**使用工具變數法處理內生性，結果發現 P_t 的係數降為 **0.15**，且變得**不顯著**，顯示 OLS 所估計的效果是偏誤的。
  同時，**plag（落後利潤）與 klag（落後資本）**的係數在 2SLS 下仍顯著，甚至效果更強。

(e)

```
lm(formula = i ~ phat + plag + klag, data = df)

Residuals:
    Min      1Q  Median      3Q     Max
-3.8778 -1.0029  0.3058  0.7275  2.1831

Coefficients:
            Estimate Std. Error t value Pr(>|t|)
(Intercept) 20.27821    9.97663   2.033  0.05802 .
phat         0.15022    0.22913   0.656  0.52084
plag         0.61594    0.21531   2.861  0.01083 *
klag        -0.15779    0.04778  -3.302  0.00421 **
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Residual standard error: 1.556 on 17 degrees of freedom
Multiple R-squared:  0.837,     Adjusted R-squared:  0.8082
F-statistic: 29.09 on 3 and 17 DF,  p-value: 6.393e-07
```

第二階段 OLS 回歸（使用 $\hat{P}_t$，也就是第一階段的預測值）得出的係數估計，與 `ivreg` 所執行的 2SLS 完全相同。

但是，在手動執行的兩階段 OLS（先回歸得到 $\hat{P}_t$，再用它進行 OLS）中，**標準誤（standard errors）明顯更大**，因此得到的 **p-value 也更大**。

這種差異是因為：
手動的第二階段 OLS 忽略了 $\hat{P}_t$ 的預測誤差（也就是忘了它是估計出來的，不是固定的數），
而 `ivreg` 則正確地將這層不確定性納入計算，回傳的是 **正確的 2SLS 標準誤**。

(f)

```
> # 輸出結果
> TR2
[1] 0.7067662
> crit_val
[1] 9.487729
```

0.7068 < 9.4877　　不拒絕 H0，工具變數和結構方程式的誤差項不相關