5.6

(a) ① $H_0 = \beta_2 = 0$

   $H_1 = \beta_2 \neq 0$

   ② $\alpha = 0.05$

   ③ $T = \dfrac{\hat{\beta_2}}{se(\hat{\beta_2})} \sim t_{(n-k)}$

   ④ RR: $\{|T| = t_{0.025,60} = 2\}$

   ⑤ $t = \dfrac{3}{\sqrt{4}} = \dfrac{3}{2} \notin RR$

   ⑥ do not reject $H_0 \Rightarrow$ 無明顯證據表示 β_2 異於 0

(b) ① $H_0 : \beta_1 + 2\beta_2 = 5$

   $H_1 : \beta_1 + 2\beta_2 \neq 5$

   ② $\alpha = 0.05$

   ③ $T = \dfrac{\hat{\beta_1} + 2\hat{\beta_2} - 5}{se(\hat{\beta_1} + 2\hat{\beta_2})} \sim t_{(n-k)}$

   $Var(\hat{\beta_1} + 2\hat{\beta_2}) = 3 + 4 \cdot 4 + 2 \cdot 2 \cdot (-2) = 11$

   ④ RR: $\{|T| = t_{0.025,60} = 2\}$

   ⑤ $t = \dfrac{2 + 6 \cdot 5}{\sqrt{11}} = 0.9045 \notin RR$

   ⑥ do not reject $H_0 \Rightarrow$ 無明顯證據表明 $\beta_1 + 2\beta_2$ 異於 5

(C) ① $H_0: \beta_1 - \beta_2 + \beta_3 = 4$

$H_1: \beta_1 - \beta_2 + \beta_3 \neq 4$

② $\alpha = 0.05$

③ $T = \dfrac{\beta_1 - \beta_2 + \beta_3 - 4}{se(\beta_1 - \beta_2 + \beta_3)} \sim t_{(n-k)}$ $\quad Var(\beta_1 - \beta_2 + \beta_3) = 3 + 4 + 3 - 2 \cdot (-2) - 2 \cdot (0) + 2 \cdot 1 = 16$

④ $RR: \{|T| \geq t_{0.025, 60} = 2\}$

⑤ $t = \dfrac{2 - 3 - 1 - 4}{4} = -\dfrac{3}{2} \notin RR$

⑥ do not reject H_0: 無明顯證據顯示 $\beta_1 - \beta_2 + \beta_3$ 異於 4

5.31

(a)

```
Residuals:
     Min      1Q   Median      3Q     Max
-18.4389  -3.6774  -0.1188  4.5863  16.4986

Coefficients:
            Estimate Std. Error t value Pr(>|t|)
(Intercept)  20.8701     1.6758  12.454  < 2e-16  ***
depart        0.3681     0.0351  10.487  < 2e-16  ***
reds          1.5219     0.1850   8.225 1.15e-14  ***
trains        3.0237     0.6340   4.769 3.18e-06  ***
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Residual standard error: 6.299 on 245 degrees of freedom
Multiple R-squared:  0.5346,    Adjusted R-squared:  0.5289
F-statistic: 93.79 on 3 and 245 DF,  p-value: < 2.2e-16
```

(b)

	2.5 %	97.5 %
(Intercept)	17.5694018	24.170871
depart	0.2989851	0.437265
reds	1.1574748	1.886411
trains	1.7748867	4.272505

Intercept $= 20.8701$

⇒ 當其他變數 $=0$ 時，須花 20.8701 分鐘（base time）

Depart $= 0.3681$

⇒ 當 depart time 增加一單位，commute time 增加 0.3681 分鐘

REDS $= 1.5219$

⇒ 當 red light 增加一次，commute time 增加 1.5219 分鐘

TRAINS $= 3.0237$

⇒ 當遇到 train 增加一次，commute time 增加 3.0237 分鐘

(c) ① $H_0: \beta_3 \geq 2$

   $H_1: \beta_3 < 2$

   ② $\alpha = 0.05$

   ③ $RR = \{T < -1.657097\}$

   ④ $t = \dfrac{1.5219 - 2}{0.185} = -2.583562 \in RR$

   ⑤ reject H_0: 明顯證據證明 $\beta_3 < 2$

(d) ① $\begin{cases} H_0: \beta_4 = 3 \\ H_1: \beta_4 \neq 3 \end{cases}$

   ② $\alpha = 0.1$

   ③ $RR = \{|T| \geq 1.657097\}$

   ④ $t^* = 0.3737 \notin RR$

   ⑤ do not reject H_0: expected delay time from each train is 3 mins.

(e) ① $\begin{cases} H_0: \beta_2 \geq \frac{1}{3} \\ H_1: \beta_2 < \frac{1}{3} \end{cases}$

   ② $\alpha = 0.05$

   ③ $RR = \{T < -1.657097\}$

   ④ $t^* = 0.991 \notin RR$

   ⑤ don't reject H_0: delay time of departure by 30 mins will increase expected travel time at least 10 mins.

(f) ① $\begin{cases} H_0: \beta_4 \geq 3\beta_3 \\ H_1: \beta_4 < 3\beta_3 \end{cases}$

   ② $\alpha = 0.05$

   ③ $RR = \{T < -1.651097\}$

   ④ $t^* = -1.825 \in RR$

   ⑤ reject H_0: expected delay time from train is less than three times from red lights.

(g) ① $\begin{cases} H_0: \beta_1 + 30\beta_2 + 6\beta_3 + \beta_4 \leq 45 \\ H_1: \beta_1 + 30\beta_2 + 6\beta_3 + \beta_4 > 45 \end{cases}$

② $\alpha = 0.05$

③ $RR: \{T > 1.6516.97\}$

④ $t^* = -1.925964 \notin RR$

⑤ do not reject H_0

(h) $\begin{cases} H_0: \beta_1 + 30\beta_2 + 6\beta_3 + \beta_4 \geq 45 \\ H_1: \beta_1 + 30\beta_2 + 6\beta_3 + \beta_4 < 45 \end{cases}$ $RR: \{T < 1.651 \cdot 97\}$

$t^* = -1.926 < -1.651 \in RR$

$\Rightarrow$ reject H_0: he can be on time for his meeting on his expected commute time.

(a)

```
Residuals:
    Min      1Q  Median      3Q     Max
-1.6628 -0.3138 -0.0276  0.3140  2.1394

Coefficients:
              Estimate Std. Error t value Pr(>|t|)
(Intercept)  1.038e+00  2.757e-01   3.764 0.000175 ***
educ         8.954e-02  3.108e-02   2.881 0.004038 **
I(educ^2)    1.458e-03  9.242e-04   1.578 0.114855
exper        4.488e-02  7.297e-03   6.150 1.06e-09 ***
I(exper^2)  -4.680e-04  7.601e-05  -6.157 1.01e-09 ***
educ:exper  -1.010e-03  3.791e-04  -2.665 0.007803 **
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Residual standard error: 0.4638 on 1194 degrees of freedom
Multiple R-squared:  0.3227,    Adjusted R-squared:  0.3198
```
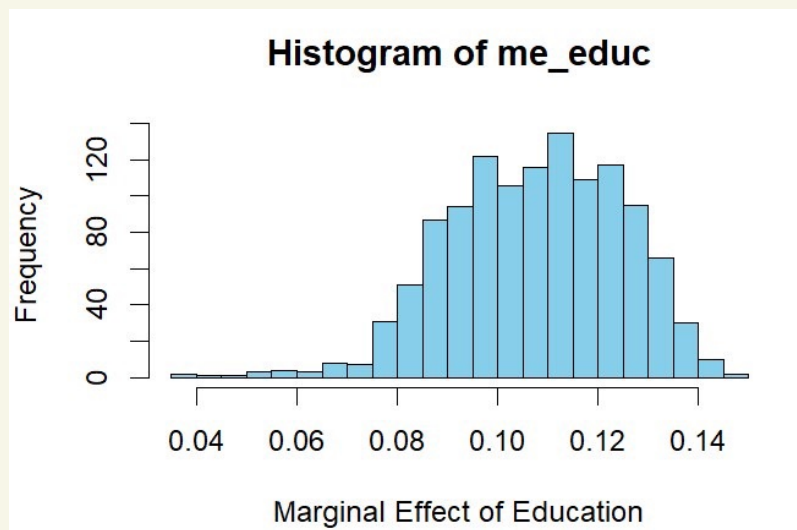
(b) $\beta_2 + 2\beta_3 EDUC + \beta_6 EXPER$

$= 0.08954 + 0.002916 \, EDUC - 0.001010 \, EXPER$

when $EDUC \uparrow \Rightarrow me \uparrow$

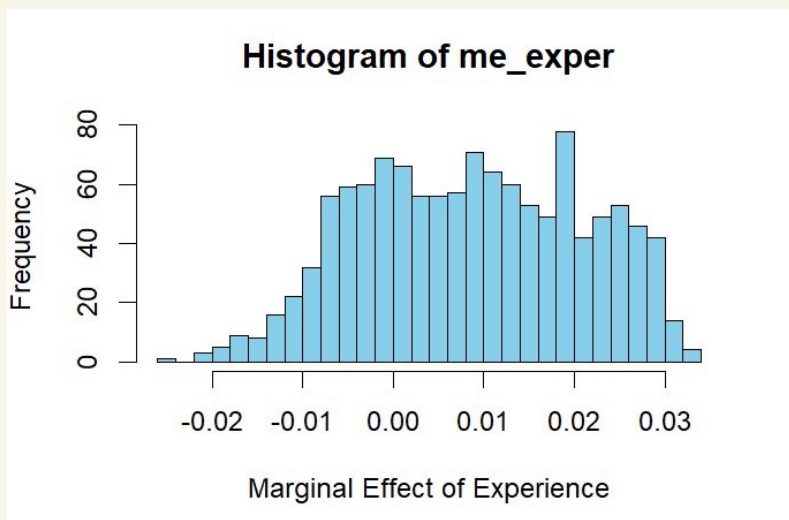$EXPER \uparrow \Rightarrow me \downarrow$

(c)

Histogram of me_educ

5%	50%	95%
0.08008187	0.10843125	0.13361880

(d) $\beta_4 + 2\beta_5 EXPER + \beta_6 EDUC$

$= 0.04488 + 2 \cdot (-0.000468) \, EXPER - 0.00101 \, EDUC$

$= 0.04488 - 0.000936 \, EXPER - 0.00101 \, EDUC$

(e)

Histogram of me_exper

	5%	50%	95%
	-0.010376212	0.008418878	0.027931151

(f) $(\beta_1 + 16\beta_2 + 256\beta_3 + 18\beta_4 + 324\beta_5 + 288\beta_6) - (\beta_1 + 17\beta_2 + 289\beta_3 + 8\beta_4 + 64\beta_5 + 136\beta_6)$

(g)
$$\begin{cases} H_0: -\beta_2 - 33\beta_3 + 10\beta_4 + 260\beta_5 + 152\beta_6 \geq 0 \\ H_1: -\beta_2 - 33\beta_3 + 10\beta_4 + 260\beta_5 + 152\beta_6 < 0 \end{cases}$$

② $\alpha = 0.05$

③ RR: $\{T < -1.67\}$

⑤ $t^* = -1.6461 \notin RR$

⑥ do not reject H_0

(g)
$$\begin{cases} H_0: -\beta_2 - 33\beta_3 + 10\beta_4 + 420\beta_5 + 144\beta_6 \geq 0 \\ H_1: -\beta_2 - 33\beta_3 + 10\beta_4 + 420\beta_5 + 144\beta_6 < 0 \end{cases}$$

$t^* = -2.062 < -1.646 \in RR \Rightarrow$ reject H_0

(h) Wendy: $\beta_4 + 34\beta_5 + 12\beta_6$
Jill: $\beta_4 + 22\beta_5 + 16\beta_6$ $\Big\rangle$ 相减
$$\begin{cases} H_0: 12\beta_5 - 4\beta_6 = 0 \\ H_1: 12\beta_5 - 4\beta_6 \neq 0 \end{cases}$$

$\alpha = 0.05$

$t^* = -1.0273$, RR: $\{|T| \geq 1.962\} \notin RR$

$\Rightarrow$ do not reject H_0

(i) $\beta_4 + 2x\beta_5 + 16\beta_6 = 0$

$$x = \frac{\beta_4 + 16\beta_6}{2\beta_5} - 11 = 19.667$$

$CI = [15.96, 23.4]$