4.4 The general manager of a large engineering firm wants to know whether the experience of technical artists influences their work quality. A random sample of 50 artists is selected. Using years of work experience (*EXPER*) and a performance rating (*RATING*, on a 100-point scale), two models are estimated by least squares. The estimates and standard errors are as follows:

Model 1:

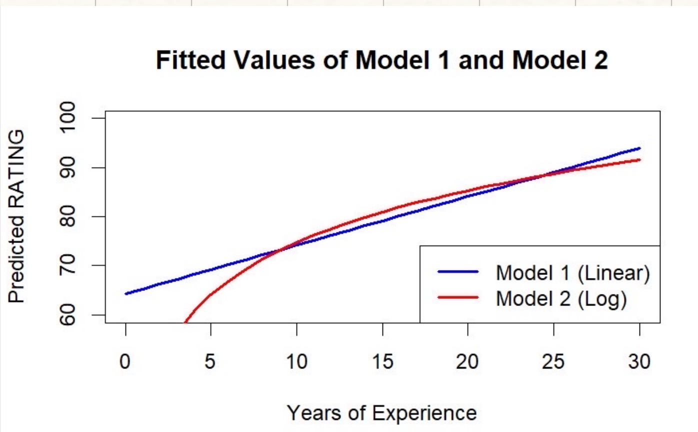
$$\widehat{RATING} = 64.289 + 0.990EXPER \quad N = 50 \quad R^2 = 0.3793$$
$$\text{(se)} \quad (2.422) \quad (0.183)$$

Model 2:

$$\widehat{RATING} = 39.464 + 15.312\ln(EXPER) \quad N = 46 \quad R^2 = 0.6414$$
$$\text{(se)} \quad (4.198) \quad (1.727)$$

a. Sketch the fitted values from Model 1 for *EXPER* = 0 to 30 years.
b. Sketch the fitted values from Model 2 against *EXPER* = 1 to 30 years. Explain why the four artists with no experience are not used in the estimation of Model 2.
c. Using Model 1, compute the marginal effect on *RATING* of another year of experience for (i) an artist with 10 years of experience and (ii) an artist with 20 years of experience.
d. Using Model 2, compute the marginal effect on *RATING* of another year of experience for (i) an artist with 10 years of experience and (ii) an artist with 20 years of experience.
e. Which of the two models fits the data better? Estimation of Model 1 using just the technical artists with some experience yields $R^2 = 0.4858$.
f. Do you find Model 1 or Model 2 more reasonable, or plausible, based on economic reasoning? Explain.

(a)(b)



因為 ln0 沒有被定義,無法計算。

(c) $\frac{d(\widehat{RATING})}{d(EXPER)} = 0.99$,邊際效果固定

The marginal effects with 10 years and 20 years of experience are equal to 0.99.

(d) $\frac{d(\widehat{RATING})}{d(EXPER)} = 15.312 \times \frac{1}{EXPER}$

The marginal effect with 10 years of experience is $15.312 \times \frac{1}{10} = 1.5312$

The marginal effect with 20 years of experience is $15.312 \times \frac{1}{20} = 0.7656$

(e) Model 1 $R^2 = 0.3793$
Model 2 $R^2 = 0.6414$
Model 1 (僅有經驗的藝術家) $R^2 = 0.4858$
由於 Model 2 $R^2 = 0.6414$ 最大,更能解釋 RATING 差異

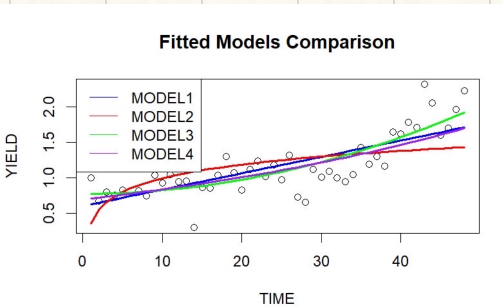
(f) Model 2 更合理,因為隨著時間增加,影響遞減較符合實際情況。

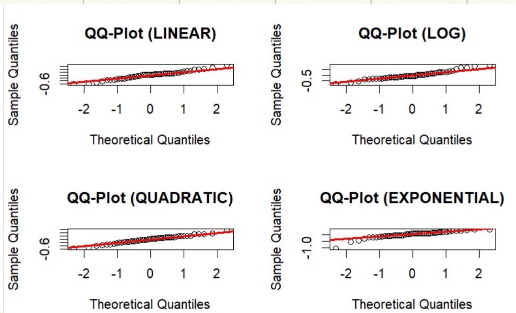
4.28 The file *wa-wheat.dat* contains observations on wheat yield in Western Australian shires. There are 48 annual observations for the years 1950–1997. For the Northampton shire, consider the following four equations:

$$YIELD_t = \beta_0 + \beta_1 TIME + e_t$$
$$YIELD_t = \alpha_0 + \alpha_1 \ln(TIME) + e_t$$
$$YIELD_t = \gamma_0 + \gamma_1 TIME^2 + e_t$$
$$\ln(YIELD_t) = \phi_0 + \phi_1 TIME + e_t$$

a. Estimate each of the four equations. Taking into consideration (i) plots of the fitted equations, (ii) plots of the residuals, (iii) error normality tests, and (iii) values for R^2, which equation do you think is preferable? Explain.
b. Interpret the coefficient of the time-related variable in your chosen specification.
c. Using your chosen specification, identify any unusual observations, based on the studentized residuals, *LEVERAGE*, *DFBETAS*, and *DFFITS*.
d. Using your chosen specification, use the observations up to 1996 to estimate the model. Construct a 95% prediction interval for *YIELD* in 1997. Does your interval contain the true value?

(a) i. ii, iii,






```
> # Shapiro-Wilk 正態性檢定 (p < 0.05 表示殘差不符合常態)
> shapiro.test(residuals(MODEL1))

        Shapiro-Wilk normality test

data:  residuals(MODEL1)
W = 0.98236, p-value = 0.6792

> shapiro.test(residuals(MODEL2))

        Shapiro-Wilk normality test

data:  residuals(MODEL2)
W = 0.96657, p-value = 0.1856
```

Model1 ~ 3 都符合 normal

```
> shapiro.test(residuals(MODEL3))

        Shapiro-Wilk normality test

data:  residuals(MODEL3)
W = 0.98589, p-value = 0.8266

> shapiro.test(residuals(MODEL4))

        Shapiro-Wilk normality test

data:  residuals(MODEL4)
W = 0.86894, p-value = 7.205e-05
```

Model4, p-value < 0.05
⇒ 不符合 normal

> summary(MODEL1)

```
Call:
lm(formula = NORTHAMPTON ~ TIME, data = DATA)

Residuals:
     Min       1Q   Median       3Q      Max 
-0.62394 -0.17302  0.03342  0.12996  0.72050 

Coefficients:
            Estimate Std. Error t value Pr(>|t|)    
(Intercept) 0.603245   0.081858   7.369 2.55e-09 ***
TIME        0.023078   0.002908   7.935 3.69e-10 ***
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Residual standard error: 0.2791 on 46 degrees of freedom
Multiple R-squared:  0.5778,	Adjusted R-squared:  0.5687 
F-statistic: 62.96 on 1 and 46 DF,  p-value: 3.689e-10
```

```
> summary(MODEL2)

Call:
lm(formula = NORTHAMPTON ~ log(TIME), data = DATA)

Residuals:
     Min       1Q   Median       3Q      Max 
-0.78488 -0.20711 -0.06382  0.15447  0.91573 

Coefficients:
            Estimate Std. Error t value Pr(>|t|)    
(Intercept)   0.3510     0.1759   1.995    0.052 .  
log(TIME)     0.2790     0.0575   4.852 1.44e-05 ***
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Residual standard error: 0.3494 on 46 degrees of freedom
Multiple R-squared:  0.3386,	Adjusted R-squared:  0.3242 
F-statistic: 23.55 on 1 and 46 DF,  p-value: 1.44e-05
```

```
> summary(MODEL3)

Call:
lm(formula = NORTHAMPTON ~ I(TIME^2), data = DATA)

Residuals:
     Min       1Q   Median       3Q      Max 
-0.56899 -0.14970  0.03119  0.12176  0.62049 

Coefficients:
             Estimate Std. Error t value Pr(>|t|)    
(Intercept) 7.737e-01  5.222e-02   14.82  < 2e-16 ***
I(TIME^2)   4.986e-04  4.939e-05   10.10 3.01e-13 ***
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Residual standard error: 0.2396 on 46 degrees of freedom
Multiple R-squared:  0.689,	Adjusted R-squared:  0.6822 
F-statistic: 101.9 on 1 and 46 DF,  p-value: 3.008e-13
```

```
> summary(MODEL4)

Call:
lm(formula = log(NORTHAMPTON) ~ TIME, data = DATA)

Residuals:
     Min       1Q   Median       3Q      Max 
-1.09292 -0.10049  0.07125  0.14140  0.40263 

Coefficients:
             Estimate Std. Error t value Pr(>|t|)    
(Intercept) -0.363938   0.076192  -4.777 1.85e-05 ***
TIME         0.018632   0.002707   6.883 1.37e-08 ***
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Residual standard error: 0.2598 on 46 degrees of freedom
Multiple R-squared:  0.5074,	Adjusted R-squared:  0.4966 
F-statistic: 47.37 on 1 and 46 DF,  p-value: 1.366e-08
```

I prefer model 3 because it R^2 is the biggest.

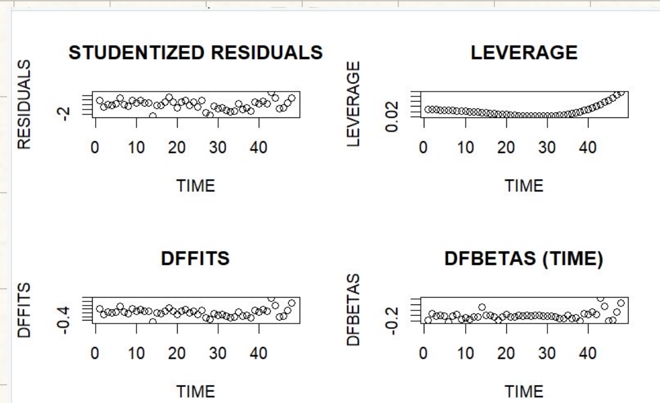
(b) From a.

$\gamma_0 = 0.7737$

當 Time = 0, Yield = 0.7737

$\gamma_1 = 0.0004986$, Yield 隨著 Time ↑, 增加越多

(c)



(d) C.I. = [1.3724, 2.3898]

YIELD = 2.2318 ∈ [1.3724, 2.3898]

Yes.