c. $\sum(x_i - \bar{x})^2 = 30.8$

$$s_{b_1} = \frac{s}{\sqrt{\Sigma(x-\bar{x})^2}} = \frac{1.453}{\sqrt{30.8}} = 0.262$$

d. $$t = \frac{b_1}{s_{b_1}} = \frac{-1.88}{0.262} = -7.18$$

Using t table (3 degrees of freedom), area in tail is less than 0.005; p-value is less than 0.01

Actual p-value = 0.0056

Because p-value $\leq \alpha$, we reject H_0: $\beta_1 = 0$

e. MSR = SSR/1 = 108.47

F = MSR/MSE = 108.47/2.11 = 51.41

Using F table (1 degree of freedom numerator and 3 denominator), p-value is less than 0.01

Actual p-value = 0.0056

Because p-value $\leq \alpha$, we reject H_0: $\beta_1 = 0$

Source of variation	Degrees of freedom	Sum of squares	Mean square	F
Regression	1	108.47	108.47	51.41
Error	3	6.33	2.11	
Total	4	114.80		

16 SSE = 233 333.33 SST = 5 648 333.33 SSR = 5 415 000

MSE = SSE/(n − 2) = 233 333.33/(6 − 2) = 58 333.33

MSR = SSR/1 = 5 415 000

F = MSR/MSE = 5 415 000/58 333.25 = 92.83

Source of variation	Degrees of freedom	Sum of squares	Mean square	F
Regression	1	5 415 000.00	5 415 000	92.83
Error	4	233 333.33	58 333.33	
Total	5	5 648 333.33		

Using F table (1 degree of freedom numerator and 4 denominator), p-value is less than 0.01

Actual p-value = 0.0006

Because p-value $\leq \alpha = 0.05$ we reject H_0: $\beta_1 = 0$. Production volume and total cost are related.

18 a. $s = 2.033$

$\bar{x} = 3 \quad \sum(x_i - \bar{x})^2 = 10$

$\hat{y} = 0.2 + 2.6x = 0.2 + 2.6(4) = 10.6$

$$s_{\hat{y}_p} = s\sqrt{\frac{1}{n} + \frac{(x_p - \bar{x})^2}{(x_i - x)^2}} = 2.033\sqrt{\frac{1}{5} + \frac{(4-3)^2}{10}} = 1.11$$

$\hat{y}_p \pm t_{\alpha/2} s_{\hat{y}_p}$

10.6 ± 3.182 (1.11) = 10.6 ± 3.53 or 7.07 to 14.13

b.

$$\hat{y}_p \pm t_{\alpha/2} s\sqrt{1 + \frac{1}{n} + \frac{(x_p - \bar{x})^2}{\sum(x_i - \bar{x})^2}} = 10.6 \pm 3.182(2.033)\sqrt{1 + \frac{1}{5} + \frac{(4-3)^2}{10}}$$

10.6 ± 3.182 (2.32) = 10.6 ± 7.38 or 3.22 to 17.98

20 $s = 1.33$

$\bar{x} = 5.2 \qquad \sum(x_i - x)^2 = 22.8$

$$s_{\hat{y}_p} = s\sqrt{\frac{1}{n} + \frac{(x_p - \bar{x})^2}{\Sigma(x_i - \bar{x})^2}} = 1.33\sqrt{\frac{1}{5} + \frac{(3-5.2)^2}{22.8}}$$

= 0.85

$\hat{y} = 0.75 + 0.51x = 0.75 + 0.51(3) = 2.28$

$\hat{y}_p \pm t_{\alpha/2} s_{\hat{y}_p}$

2.28 ± 3.182 (0.85) = 2.28 ± 2.70

or −0.40 to 4.98

$$s\sqrt{1 + \frac{1}{n} + \frac{(x_p - \bar{x})^2}{\Sigma(x_i - x)^2}} \qquad \sqrt{1 + \frac{1}{5} + \frac{(3-5.2)^2}{22.8}} = 1.58$$

$\hat{y}_p \pm t_{\alpha/2}$ (1.58) =

2.28 ± 3.182 (1.58) = 2.28 ± 5.03

or −2.27 to 7.31

22 a. 9

b. $\hat{y} = 20.0 + 7.21x$

c. 1.3626

d. SSE = SST − SSR = 51 984.1 − 41 587.3 = 10 396.8

MSE = 10 396.8/7 = 1485.3

F = MSR/MSE = 41 587.3/1485.3 = 28.00

Using F table (1 degree of freedom numerator and 7 denominator), p-value is less than 0.01

Actual p-value = 0.0011

Because p-value $\leq \alpha$, we reject H_0: $\beta_1 = 0$.

e. $\hat{y} = 20.0 + 7.21(50) = 380.5$ or €380 500

24 a. $\hat{y} = 80.0 + 50.0x$

b. 30

c. F = MSR/MSE = 6828.6/82.1 = 83.17

Using F table (1 degree of freedom numerator and 28 denominator), p-value is less than 0.01

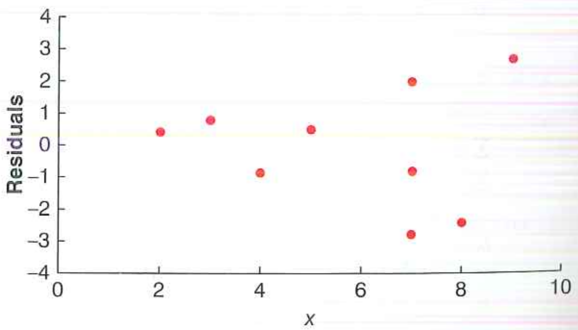
Actual p-value = 0.0001

Because p-value $< \alpha = 0.05$, we reject H_0: $\beta_1 = 0$. Branch office sales are related to the salespersons.

d. $\hat{y} = 80 + 50\,(12) = 680$ or €680 000

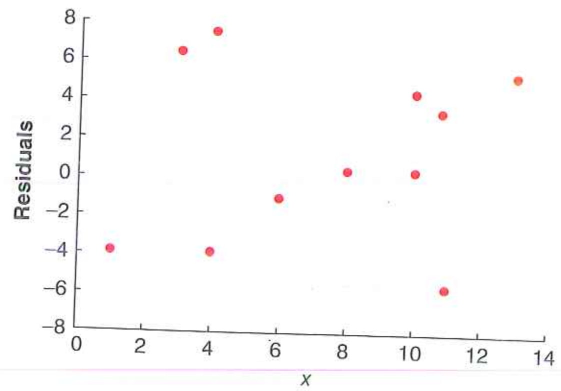
26 a. $\hat{y} = 2.32 + 0.64x$

b.



The assumption that the variance is the same for all values of x is questionable. The variance appears to increase for larger values of x.

28 a. $\hat{y} = 80 + 4x$



b. The assumptions concerning the error term appear reasonable.

30 a. The MINITAB output is shown below:

```
The regression equation is
Y = 13.0 + 0.425 X

Predictor    Coef     SE Coef     T       p
Constant   13.002     2.396      5.43   0.002
X           0.4248    0.2116     2.01   0.091

S = 3.181   R-sq = 40.2%   R-sq(adj) = 30.2%

Analysis of Variance

SOURCE            DF     SS      MS      F      p
Regression         1   40.78   40.78   4.03   0.091
Residual Error     6   60.72   10.12
Total              7  101.50

Unusual Observations

                               Stdev.              St.
Obs.   X      Y      Fit       Fit    Residual  Resid
 7   12.0   24.00   18.10     1.20     5.90     2.00R
 8   22.0   19.00   22.35     2.78    -3.35    -2.16RX

R denotes an observation with a large stan-
dardized residual.
X denotes an observation whose X value gives
it a large influence.
```

The standardized residuals are: −1.00, −0.41, 0.01, −0.48, 0.25, 0.65, −2.00, −2.16

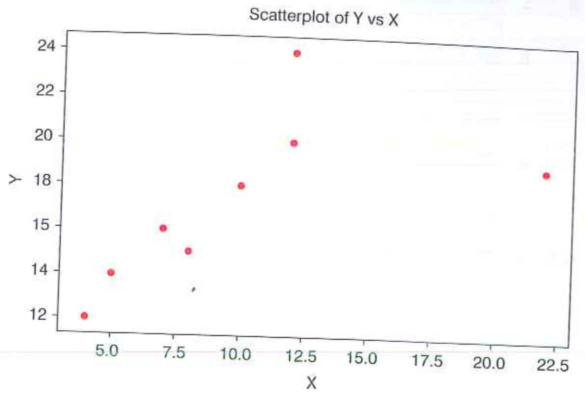
The last two observations in the data set appear to be outliers since the standardized residuals for these observations are 2.00 and −2.16, respectively.

b. Using MINITAB, we obtained the following leverage values:

0.28, 0.24, 0.16, 0.14, 0.13, 0.14, 0.14, 0.76

MINITAB identifies an observation as having high leverage if $h_i > 6/n$: for these data, $6/n = 6/8 = 0.75$. Since the leverage for the observation $x = 22$, $y = 19$ is 0.76, MINITAB would identify observation 8 as a high leverage point. Thus, we conclude that observation 8 is an influential observation.

c.



The scatter diagram indicates that the observation $x = 22$, $y = 19$ is an influential observation.

Chapter 15

Solutions

2 a. The estimated regression equation is

$\hat{y} = 45.06 + 1.94x_1$

An estimate of Y when $x_1 = 45$ is

$\hat{y} = 45.06 + 1.94(45) = 132.36$

b. The estimated regression equation is

$\hat{y} = 85.22 + 4.32x_2$

An estimate of y when $x_2 = 15$ is

$\hat{y} = 85.22 + 4.32(15) = 150.02$

c. The estimated regression equation is

$\hat{y} = -18.37 + 2.01x_1 + 4.74x_2$

An estimate of y when $x_1 = 45$ and $x_2 = 15$ is

$\hat{y} = -18.37 + 2.01(45) + 4.74(15) = 143.18$

4 a. $\hat{y} = 25 + 10(15) + 8(10) = 255$: sales estimate: €255 000

b. Sales can be expected to increase by €10 for every dollar increase in inventory investment when advertising expenditure is held constant. Sales can be expected to increase by €8 for every dollar increase in advertising expenditure when inventory investment is held constant.

6 a. The MINITAB output is shown below:

```
The regression equation is
Return = 247 - 32.8 Safety   34.6 ExpRatio
Predictor      Coef     SE Coef       T        P
Constant      247.4      110.4       2.24    0.039
Safety       -32.84      13.95      -2.35    0.031
ExpRatio      34.59      14.13       2.45    0.026

S = 16.98  R-Sq = 58.2%  R-Sq(adj) = 53.3%

Analysis of Variance

Source           DF      SS       MS       F      P
Regression        2   6823.2   3411.6  11.84  0.001
Residual Error   17   4899.7    288.2
Total            19  11723.0
```

b. $\hat{y} = 247 - 32.8(7.5) + 34.6(2) = 70.2$