

Introduction to Econometric Theory
1st edition Davidson Solutions
Manual

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An Introduction to Econometric Theory: Solutions Manual for the Exercises

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Chapter 1

Elementary Data Analysis: Exercises

1. *Are the following statements True or False?*

- (a) *The correlation of a variable with itself is always 1.*

TRUE. Put $y_t = x_t$ in (1.11)

- (b) *Chebyshev's rule says that at least a proportion $1/m^2$ of any sample lies beyond m standard deviations from the mean.*

FALSE. "At most", not "At least".

- (c) *The least absolute values fitting method is more influenced by outlying observations than least squares.*

FALSE. Less not more.

- (d) *The sample mean is the least squares measure of location.*

TRUE, see (1.29).

- (e) *The slope coefficient in the simple regression is the tangent of the angle of the regression line with the horizontal axis.*

TRUE, see Figure 1.3

- (f) *The least squares estimator of the slope coefficient (y on x) is the sum of the products of y with the mean deviations of x , divided by the sum of squares of the mean deviations of x .*

TRUE, see (1.27).

- (g) *Run a regression in both directions (y on x and x on y), and the product of the two slope coefficients is equal to the squared correlation coefficient.*

TRUE, compare (1.11) with (1.27).

2. *Here are 12 observations on a variable x :*

$86, 109, 81, 53, 86, -14, 65, -39, 65, 34, 79, -27$

- (a)
- Compute the mean.*

$$\bar{x} = 48.1667$$

- (b)
- Compute the sequence of mean deviations.*

$$60.83, 32.83, 4.83, 37.83, -62.17, 16.83, -87.17, 16.83, -14.17, 30.83, -75.17$$

- (c)
- Compute the standard deviation.*

$$s = 49.0785$$

- (d)
- How many of these data points lie more than (i) one, (ii) two, (iii) three standard deviations from the mean?*

(i) 1 SD bounds: $[-0.91, 97.24]$ and 4/12 lie outside.(ii) 2SD bounds: $[-49.99, 146.32]$ and none lie outside.

- (e)
- Include the following observations in the set, and obtain the mean and standard deviation for this case.*

$$209, 475, -114, 46$$

$$\bar{x} = 74.625, \quad s = 129.009$$

- (f)
- Repeat exercise (d) for the enlarged data set.*

(i) 1 SD bounds: $[-54.38, 203.63]$ and 3/12 lie outside.(ii) 2SD bounds: $[-183.99, 332.64]$ and none lie outside.

- 3.
- Here are 12 observations on a variable y .*

$$43, 62, 26, 46, 48, 3, 52, -10, 37, 5, 42, 4$$

- (a)
- Compute the mean.*

$$\bar{x} = 29.833$$

- (b)
- Compute the standard deviation.*

$$s = 23.54$$

- (c)
- Compute the correlation coefficient of y with x in Question 1.*

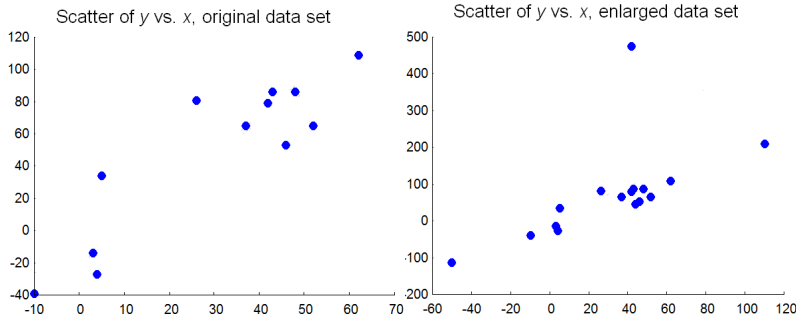
$$r = 0.896$$

- (d)
- Include the following data points in the set and compute the correlation coefficient with the enlarged data set of Question 1.*

$$110, 42, -50, 44$$

$$r = 0.602$$

(e) Draw scatter plots of the two cases



4. Compute the regression of y on x (original sample).

(a) Report the fitted slope and intercept coefficients and the residuals, $\hat{u}$.

$$\hat{y} = 9.11 + 0.43x$$

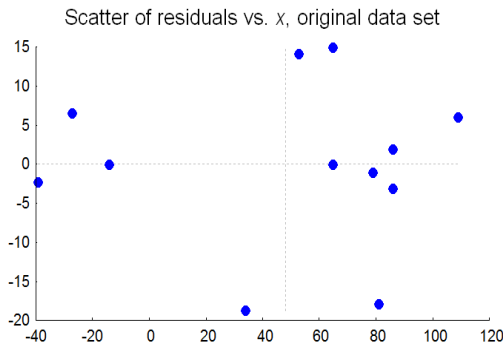
Residuals:

$-3.1, 5.99, -17.96, 14.09, 1.89, -0.091, 14.93, -2.34, -0.074, -18.7, -1.09, 6.5$

Fitted values:

$46.11, 56, 43.96, 31.91, 46.11, 3.09, 37.07, -7.66, 37.07, 23.74, 43.1, -2.5$

(b) Verify that $\hat{u}$ has zero correlation with x . Draw the scatter plot of the two variables.



Correlation coefficient is zero.

(c) Consider the prediction equation

$$\check{y} = 5 + 0.6x$$

Show that the prediction errors in this case are correlated with x , and also have a larger mean squared error than the regression predictions.

The predictions are

$56.6, 70.4, 53.6, 36.8, 56.6, -3.4, 44, -18.4, 44, 25.4, 52.4, -11.2$

Correlation with x is -0.62 . MSE is 194.47. MSE of the least squares residuals is 108.45

- (d) *Compute the regression of y on x (extended sample). Report the fitted coefficients and comment*

$$\hat{y} = 19.037 + 0.167x.$$

Comment: large shift in the coefficients shows that extreme observations are influential in the least squares fit. See scatter plot - a single observation makes the difference.

5.

- (a) *Solve the following equation system for $\hat{\beta}_1$.*

$$\hat{\beta}_1 \sum_{t=1}^T x_{1t}^2 + \hat{\beta}_2 \sum_{t=1}^T x_{1t}x_{2t} = \sum_{t=1}^T x_{1t}y_t \quad (1)$$

$$\hat{\beta}_1 \sum_{t=1}^T x_{2t}x_{1t} + \hat{\beta}_2 \sum_{t=1}^T x_{2t}^2 = \sum_{t=1}^T x_{2t}y_t \quad (2)$$

First step: get $\hat{\beta}_2$ a function of $\hat{\beta}_1$ in equation (2)

$$\hat{\beta}_2 = \frac{\sum_{t=1}^T x_{2t}y_t - \hat{\beta}_1 \sum_{t=1}^T x_{2t}x_{1t}}{\sum_{t=1}^T x_{2t}^2}$$

Second step. Substitute into equation (1)

$$\hat{\beta}_1 \sum_{t=1}^T x_{1t}^2 + \sum_{t=1}^T x_{2t}y_t - \hat{\beta}_1 \sum_{t=1}^T x_{2t}x_{1t} = \sum_{t=1}^T x_{1t}y_t - \hat{\beta}_1 \sum_{t=1}^T x_{1t}x_{2t}$$

Third step. Solve for $\hat{\beta}_1$

$$\hat{\beta}_1 = \frac{\sum_{t=1}^T x_{1t}y_t \sum_{t=1}^T x_{2t}^2 - \sum_{t=1}^T x_{2t}y_t \sum_{t=1}^T x_{1t}x_{2t}}{\sum_{t=1}^T x_{1t}^2 \sum_{t=1}^T x_{2t}^2 - \left(\sum_{t=1}^T x_{2t}x_{1t} \right)^2}.$$

- (b) *Define $\hat{\alpha} = \bar{y} - \hat{\beta}_1\bar{x}_1 - \hat{\beta}_2\bar{x}_2$. Show that if $T\hat{\alpha}\bar{x}_1$ is subtracted from the right-hand side of equation (1), and $T\hat{\alpha}\bar{x}_2$ is subtracted from the right-hand side of equation (2), the resulting equations are modified by having the variables expressed in mean deviation form.*

$$\hat{\beta}_1 \sum_{t=1}^T x_{1t}^2 + \hat{\beta}_2 \sum_{t=1}^T x_{1t}x_{2t} = \sum_{t=1}^T x_{1t}y_t - T(\bar{y} - \hat{\beta}_1\bar{x}_1 - \hat{\beta}_2\bar{x}_2)\bar{x}_1$$

$$\hat{\beta}_1 \sum_{t=1}^T x_{2t}x_{1t} + \hat{\beta}_2 \sum_{t=1}^T x_{2t}^2 = \sum_{t=1}^T x_{2t}y_t - T(\bar{y} - \hat{\beta}_1\bar{x}_1 - \hat{\beta}_2\bar{x}_2)\bar{x}_2$$

are the same as

$$\begin{aligned}\hat{\beta}_1 \left(\sum_{t=1}^T x_{1t}^2 - T\bar{x}_1^2 \right) + \hat{\beta}_2 \left(\sum_{t=1}^T x_{1t}x_{2t} - T\bar{x}_1\bar{x}_2 \right) &= \left(\sum_{t=1}^T x_{1t}y_t - T\bar{y}\bar{x}_1 \right) \\ \hat{\beta}_1 \left(\sum_{t=1}^T x_{2t}x_{1t} - T\bar{x}_1\bar{x}_2 \right) + \hat{\beta}_2 \left(\sum_{t=1}^T x_{2t}^2 - T\bar{x}_2^2 \right) &= \left(\sum_{t=1}^T x_{2t}y_t - T\bar{y}\bar{x}_2 \right)\end{aligned}$$

(c) What is $\hat{\alpha}$?

Write the equations as

$$\begin{aligned}\hat{\beta}_1 \sum_{t=1}^T x_{1t}^2 + \hat{\beta}_2 \sum_{t=1}^T x_{1t}x_{2t} + \hat{\alpha} \sum_{t=1}^T x_{1t} &= \sum_{t=1}^T x_{1t}y_t \\ \hat{\beta}_1 \sum_{t=1}^T x_{2t}x_{1t} + \hat{\beta}_2 \sum_{t=1}^T x_{2t}^2 + \hat{\alpha} \sum_{t=1}^T x_{2t} &= \sum_{t=1}^T x_{2t}y_t \\ \hat{\beta}_1 \sum_{t=1}^T x_{1t} + \hat{\beta}_2 \sum_{t=1}^T x_{2t} + T\hat{\alpha} &= \sum_{t=1}^T y_t\end{aligned}$$

and these are the normal equations with intercept, with the solution for $\hat{\alpha}$ indicated.

6. Show that the α that minimizes $\sum_{t=1}^T (y_t - \alpha)^2$ is the sample mean of $y_1, \dots, y_T$.

Write

$$\begin{aligned}\sum_{t=1}^T (y_t - \alpha)^2 &= \sum_{t=1}^T (y_t - \bar{y} + \bar{y} - \alpha)^2 \\ &= \sum_{t=1}^T (y_t - \bar{y})^2 + T(\bar{y} - \alpha)^2 + 2(\bar{y} - \alpha) \sum_{t=1}^T (y_t - \bar{y}) \\ &\geq \sum_{t=1}^T (y_t - \bar{y})^2\end{aligned}$$

because

$$\sum_{t=1}^T (y_t - \bar{y}) = 0.$$