14. With respect to autocorrelation, explain (*a*) what it is and why it is a problem, (*b*) how it can be detected, and (*c*) how it can be overcome.

15. (*a*) On what does the domestic-currency price of a nation's imports depend? (*b*) What would happen to the domestic-currency price of a nation's imports if the foreign-currency price of the nation's imports increases and the nation's currency depreciates (i.e., loses value in relation to the foreign currency)?

PROBLEMS

1. With the aid of a figure, show why (*a*) if the observed price-quantity data points fall more or less downward and to the right, we can derive the demand curve for the commodity, but (*b*) if the observed price-quantity data points are clustered or bunched together, we cannot derive the demand curve for the commodity.

*2. Draw two figures: (*a*) one showing that if the demand curve did not shift but the supply curve did, we could derive the demand curve for the commodity by simply connecting the observed price-quantity data points and (*b*) the other showing that if the supply curve did not shift but the demand curve did, we could derive the supply curve of the commodity by simply connecting the observed price-quantity data points. (*c*) In which sector of the economy is each of these cases most likely to occur? Why?

*3. From Table 5-1 in the text, which gives the price elasticity of demand for Florida Indian River oranges, Florida interior oranges, and California oranges, as well as the cross-price elasticities among them, determine (*a*) by how much the quantity demanded of each type of orange would change if its price were reduced by 10 percent, (*b*) whether the sellers' total revenues would increase, decrease, or remain unchanged with the 10 percent decrease in price, and (*c*) whether the sellers' profits would increase, decrease, or remain unchanged with the 10 percent decrease in price.

4. From Table 5-1 in the text, determine by how much the demand for Florida Indian River oranges would change as a result of a 10 percent increase in the price of Florida interior oranges, and vice versa.

5. Estimate by hand calculation the regression equation of the firm's sales revenue (Y) on its quality control expenditure (call it Z) for the data given in Table 5-6. (*b*) Plot the estimated regression equation in a graph that also shows the data points and the errors. (*c*) What would be the sales revenue of the firm when the firm's expenditure on quality control is $2 million per year? $9 million per year? Why would you expect these results to be greatly biased?

*6. From the following table giving the quantity demanded of a commodity (Y), its price (X_1), and consumer income (X_2) from 1986 to 2005, (*a*) estimate the regression equation of Y on X_1 and X_2, (*b*) test at the 5 percent level for the statistical significance of the slope parameters, (*c*) find the unadjusted and the adjusted coefficients of determination, and (*d*) test at the 5 percent level for the overall statistical significance of the regression. Show all your results to three decimal places. [If you have not used the computer before, ask a fellow student to show you how to run the regression. If this is not possible, from the answer to part (*a*) of this question provided at the end of the book, answer parts (*b*), (*c*), and (*d*).]

Year	Y	X_1	X_2
1986	72	$10	$2,000
1987	81	9	2,100
1988	90	10	2,210
1989	99	9	2,305
1990	108	8	2,407
1991	126	7	2,500
1992	117	7	2,610
1993	117	9	2,698
1994	135	6	2,801
1995	135	6	2,921
1996	144	6	3,000
1997	180	4	3,099
1998	162	5	3,201
1999	171	4	3,308
2000	153	5	3,397
2001	180	4	3,501
2002	171	5	3,689
2003	180	4	3,800
2004	198	4	3,896
2005	189	4	3,989

TABLE 5-6 Yearly Expenditures on Advertising and Quality Control, and Sales of the Firm (millions of dollars)

Year (t)	1	2	3	4	5	6	7	8	9	10
Advertising (X_1)	10	9	11	12	11	12	13	13	14	15
Quality control (X_2)	3	4	3	3	4	5	6	7	7	8
Sales revenue (Y)	44	40	42	46	48	52	54	58	56	60

The only assumptions made in multiple regression analysis in addition to those made for simple regression analysis are that the number of independent or explanatory variables in the regression be smaller than the number of observations and that there be no perfect linear correlation among the independent variables.[10]

The process of estimating the parameters or coefficients of a multiple regression equation is, in principle, the same as in simple regression analysis, but since the calculations are much more complex and time-consuming, they are invariably done with computers. The computer also provides routinely the standard error of the estimates, the t statistics, the coefficient of multiple determination, and several other important statistics that are used to conduct other statistical tests of the results (to be examined later). All that is required is to be able to set up the regression analysis, feed the data into the computer, and interpret the results.

For example, if we regress the firm's sales (Y) on its expenditures for advertising (X_1) and quality control (X_2) using the data in Table 5-6 (an extension of Table 5-2), we obtain the results given in Table 5-7.[11]

From the results shown in Table 5-7, we can write the following regression equation:

$$\hat{Y}_t = 17.944 + 1.873X_{1t} + 1.915X_{2t} \qquad [5\text{-}19]$$

$$t \text{ statistic} \qquad (2.663) \qquad (2.813)$$

These results indicate that for each \$1 million increase in expenditures on advertising and quality control, the sales of the firm increase by \$1.87 million (the estimated coefficient of X_1) and \$1.92 million (the estimated coefficient of X_2), respectively. To perform t tests for the statistical significance of the estimated parameters or coefficients, we need to determine the critical value of t from the table of the t distribution. At the 0.05 level of significance for $n - k = 10 - 3 = 7$ df (where k is the number of estimated parameters, including the constant term), this is 2.365, obtained by going down the column headed 0.05 in Table C-2 (for the two-tailed test with 2.5 percent of the area under each tail of the t distribution) until we reach 7 df. Since the value of the calculated t statistic exceeds the

[10] If the number of independent or explanatory variables (the X's) is equal to or larger than the number of observations, or if there is an exact linear relationship among some or all of the independent or explanatory variables, the regression equation cannot be estimated.

[11] The results given in Table 5-7 are in the form provided by a standard computer program (TSP). Other computer programs (such as SPSS, EViews, and RATS) usually provide the same general information in a similar format. Different computer programs, however, usually give slightly different results because of differences in rounding.

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R
1																		
2		Country:*	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	
3		Y_i	76	10	44	47	23	19	13	19	8	44	4	31	24	59	37	
4		X_i	6	16	9	8	14	11	12	10	18	5	26	8	8	9	5	
5																		

Key: (1) Argentina; (2) Bolivia; (3) Brazil; (4) Chile; (5) Colombia; (6) Dominican Republic; (7) Ecuador; (8) El Salvador; (9) Honduras; (10) Mexico; (11) Nicaragua; (12) Panama; (13) Peru; (14) Uruguay; (15) Venezuela.

Source: World Bank World Development Indicators.

2. *(a)* Estimate the regression in Problem 5 based on Table 5-6 using Excel's regression function in the Data Analysis menu. *(b)* Using the coefficients found in the regression estimate, enter a formula based in cells C6 through J6 to forecast the sales revenue when quality control goes from $2 million to $9 million a year. *(c)* Graph both the actual data and the forecast using the graphing tool. Does the forecast vary much from the actual data?

	A	B	C	D	E	F	G	H	I	J	K	L	M
1													
2		Quality Control (Z)	3	4	3	3	4	5	6	7	7	8	
3		Sales Revenue (Y)	44	40	42	46	48	52	54	58	56	60	
4													
5		Z	2	3	4	5	6	7	8	9			
6		Y Forecast											
7													

3. The following table gives the real per capita income in thousands of U.S. dollars (Y) with the percentage of the labor force in agriculture (X_1) and the average years of schooling of the population over 25 years of age (X_2) for 15 developed countries in 1981. *(a)* Find the least-squares regression equation of Y on X_1 and X_2 using Excel's Data Analysis tool. *(b)* Interpret the results of *(a)*.

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R
1																		
2		n	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	
3		Y	6	8	8	7	7	12	9	8	9	10	10	11	9	10	11	
4		X_1	9	10	8	7	10	4	5	5	6	8	7	4	9	5	8	
5		X_2	8	13	11	10	12	16	10	10	12	14	12	16	14	10	12	
6																		

SUPPLEMENTARY READINGS

For a classical discussion on demand estimation, see:

Schultz, Henry, *Theory and Measurement of Demand* (Chicago: University of Chicago Press, 1964).

Working, E. J., "What Do Statistical 'Demand Curves' Show?" *Quarterly Journal of Economics* (1927).

The use of regression analysis in demand estimation is discussed in:

Berk, K. N., and P. Carey, *Data Analysis with Microsoft Excel* (Duxbury, Mass.: Duxbury Press, 1995).