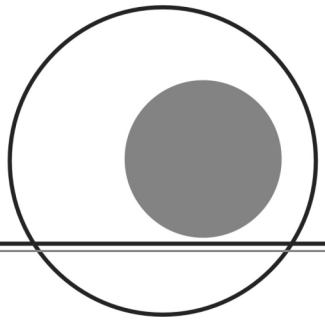

Online Topic 1: Estimating and Forecasting Industry Demand for Price-Taking Firms

Learning Objectives

After reading Online Topic 1 and working the problems online and in this supplemental section of your Student Workbook, you should be able to:

- Distinguish between "market-determined" and "manager-determined" prices and know whether to use the ordinary least-squares (OLS) or the two-stage least-squares (2SLS) method to estimate demand.
- For price-taking firms that face market-determined prices, you will learn to:
  - determine whether the industry demand and supply function are identified.
  - estimate industry demand (and supply) using two-stage least-squares (2SLS)

Essential Concepts

1. The method of estimating the parameters of an empirical demand function depends on whether the price of the product is *market-determined* or *manager-determined*. Managers of price-taking firms do not set the price of the product they sell; rather, prices are endogenous or "market-determined" by the intersection of demand and supply. Managers of price-setting firms set the price of the product they sell by producing the quantity associated with the chosen price on the downward sloping demand curve facing the firm. Since price is manager-determined rather than market-determined, price is exogenous for price-setting firms.

2. When estimating industry demand for price-taking firms, the *problem of simultaneity* must be addressed. The simultaneity problem arises because the observed variation in equilibrium output and price is the result of changes in the determinants of both demand and supply. Because output and price are determined jointly by the forces of supply and demand, two econometric problems arise when a researcher tries to estimate the coefficients of demand: (i) the *identification problem* and (ii) the *simultaneous equations bias* problem.

   (i) An industry demand equation is identified when it is possible to estimate the true demand function from a sample of observations of equilibrium output and price. Industry demand is identified when supply includes at least one exogenous variable that is not also in the demand equation.

   (ii) When market price is an endogenous variable, price will be correlated with the random error term in the demand equation, causing a simultaneous equations bias if the ordinary least-squares (OLS) method of estimation is applied. To avoid simultaneous equations bias, the two-stage least-squares

method of estimation (2SLS) can be employed if the industry demand equation is identified.

3. The following steps, which are discussed in detail in the textbook (pp. 260–62), can be followed to estimate an industry demand function for a price-taking firm:

   Step 1: Specify the industry demand and supply equations.

   Step 2: Check for identification of industry demand.

   Step 3: Collect data for the variables in demand and supply.

   Step 4: Estimate industry demand using 2SLS.

4. Econometric models are statistical models that use an explicit model of the economic structure of a marketplace to explain and forecast the values of economic variables that are endogenous to the model. The technique of forecasting with simultaneous equations employs an estimated demand function and an estimated supply function to produce a forecasted value for sales (and price). The procedure can be summarized as follows:

   Step 1: The current (or prevailing) demand and supply functions are estimated using currently available data. Both equations must be identified, and both are estimated using two-stage least-squares (2SLS).

   Step 2: Future (forecasted) values of the exogenous variables are obtained either by estimation (e.g., linear trend forecasting) or from one of the forecasting models used by government agencies or private firms. The forecasted values of the exogenous variables are substituted into the demand and supply equations to obtain equations in the forecast period.

   Step 3: The intersection of the future demand and supply equations is found. The values of P and Q at the intersection are the forecast values of sales and price for that period in the future.

Matching Definitions

econometric models
endogenous variable
exogenous variable
identification of demand
ordinary least-squares (OLS)
reduced-form equation
simultaneity problem
simultaneous equations bias
two-stage least-squares (2SLS)

1. _____ A variable that is determined by a system of equations.
2. _____ A variable in a system of equations whose value is determined outside the system.
3. _____ Another name for standard regression analysis.
4. _____ A problem in estimating market demand that arises because variation in observed values of market quantity and price are simultaneously determined by changes in both supply and demand.
5. _____ An equation that expresses an endogenous variable as a function of the exogenous variables and random error terms.
6. _____ Determining whether the sample data will trace out the true demand curve.
7. _____ A method of estimating parameters of demand when price is endogenous or market-determined.
8. _____ A bias in estimating regression parameters that occurs when ordinary least squares (OLS) is used to estimate parameters of an equation for which one or more of the explanatory variables is an endogenous variable.
9. _____ Statistical models that use an explicit structural model to explain the underlying economic relations.

Study Problems

1. Under what circumstances is it appropriate to estimate demand using the method of two-stage least-squares (2SLS)?

2. Suppose both the quantity demanded and the quantity supplied are specified to be functions of price only:

$$\textit{Demand}: \quad Q = a + bP$$

$$\textit{Supply}: \quad Q = e + fP$$

   a. Can you estimate this demand function using ordinary regression analysis?

   b. Suppose you added income (M) to the demand specification:

$$\textit{Demand}: \quad Q = a + bP + cM$$

   Is demand identified now? Why or why not?

   c. Suppose that the price of labor (P_w) is added to the supply specification:

Supply: $Q = e + fP + gP_w$

Is demand identified now? Why or why not?

3. The following industry demand function for good X was estimated using 2SLS:

$$Q = a + bP + cM + dP_R$$

The demand function was first identified by specifying the supply function. The estimation results are:

Two-Stage Least-Squares Estimation

DEPENDENT VARIABLE: QX

OBSERVATIONS: 275

VARIABLE	PARAMETER ESTIMATE	STANDARD ERROR	T-RATIO	P-VALUE
INTERCEPT	9500.4	3350.6	2.84	0.0049
P	–12.75	4.30	–2.87	0.0044
M	–0.0163	0.0066	–2.49	0.0135
PR	5.05	1.10	4.59	0.0001

a. Is the sign of $\hat{b}$ as we would have predicted? Why or why not?

b. Is this good normal or inferior good? Explain.

c. Are goods *X* and *R* substitutes or complements? Explain.

d. Which coefficients are significant at the 5 percent level of significance? Explain.

e. Using the values P = \$20, M = \$50,000, and P_R = \$100, calculate estimates of the following:

(i) The price elasticity of demand is _____.

(ii) The cross-price elasticity of demand is _____.

(iii) The income elasticity of demand is _____.

4. The following demand and supply functions are specified for the U.S. housing market:

Demand: $Q_H = a + bP_H + cM + dP_A + eR$

Supply: $Q_H = f + gP_H + hP_M$

The variables are measured in the following way:

Q_H = thousands of new homes sold

P_H = the median price of a new home in thousands of dollars

M = the median household income

P_A = the median monthly rental rate on apartments

R = the mortgage interest rate

P_M = an index of building materials prices

Using quarterly data for the period 1998I through 2007I, these equations are estimated using 2SLS:

Demand: $Q_H = 504{,}500 - 10.0P_H + 5M + 500P_A - 11{,}750R$

Supply: $Q_H = 326{,}000 + 15.0P_H - 1{,}800P_M$.

The predicted values for the exogenous variables for the first quarter of 2008 are obtained from a private econometrics firm. The predicted values are:

$M = \$52{,}000$ $P_A = \$400$ $R = 14\%$ $P_M = 320$

a. Are the signs of the estimated coefficients as would be expected? Explain why for each one.

b. Forecast the price of housing in 2008I.

c. Forecast the sales of housing in 2008 I.

Computer Problem

Use a computer regression package, such as the Student Edition of Statistix 8, and the following annual data for rutabagas in the United States to work this computer problem.

Year	Q	P	A	W
1980	4,459,637	4.5	49,500	115.6
1981	4,612,484	6.3	50,250	113.0
1982	4,941,674	7.9	49,000	110.5
1983	4,660,353	2.6	49,750	121.8
1984	5,272,535	7.4	54,000	118.2
1985	4,973,639	13.6	60,250	105.9
1986	5,439,800	8.2	48,250	112.9
1987	5,447,964	9.9	60,100	118.2
1988	5,428,675	12.7	62,750	113.4
1989	5,789,963	15.2	65,400	112.1
1990	5,238,036	11.5	58,500	111.6
1991	5,567,663	14.9	66,300	111.8
1992	5,150,214	15.3	67,800	109.0
1993	6,109,218	12.1	66,000	122.3
1994	5,746,473	19.1	72,250	107.8
1995	4,707,301	10.5	55,000	107.2
1996	5,365,661	7.1	53,400	119.1
1997	5,938,797	23.0	80,164	106.0
1998	6,125,474	19.1	84,000	119.7
1999	5,936,636	9.6	56,500	119.6
2000	5,131,297	12.3	62,000	111.6

Q is the number of pounds of rutabagas produced and sold annually in the United States, *P* is the inflation-adjusted price of rutabagas (in cents per pound), *A* is the inflation-adjusted annual expenditure on advertising (in dollars per year) by the American Rutabaga Growers Association (ARGA), and *W* is a weather index based on temperature and rainfall in the primary rutabaga-growing regions (*W* varies directly with conduciveness of weather for growing rutabagas).

a. Given the data provided in the table above, specify a linear empirical demand function for rutabagas in the United States:

$$Q = \_\_\_\_\_.$$

b. Should you use the ordinary least-squares (OLS) method or the two-stage least-squares (2SLS) method for estimating the market demand for rutabagas? Explain.

c. Given the data provided in the table above, specify a linear empirical supply function for rutabagas that will ensure the demand function specified in part *a* is identified:

$$Q = \_\_\_\_\_.$$

d. Using your statistical software, estimate the parameters of the empirical demand function specified in part *a*. Write your estimated demand for rutabagas:

$$\hat{Q}_d = \_\_\_\_\_.$$

Are the estimated slope parameters statistically significant at the 10 percent level?

e. What is the price elasticity of demand for rutabagas measured at the sample mean values of price and advertising? Is the demand for rutabagas elastic, inelastic, or unitary elastic when measured at the sample mean values of P and A? By approximately what percentage amount would the price of rutabagas have to fall in order for quantity demanded to increase by 5 percent?

f. What is the advertising elasticity of demand for rutabagas measured at the sample mean values of price and advertising? Approximately what percentage change in advertising would cause demand for rutabagas to increase by 5 percent?

g. Should you use the ordinary least-squares (OLS) method or the two-stage least-squares method (2SLS) method for estimating the market supply for rutabagas? Explain.

h. Using your statistical software, estimate the linear supply function that you suggested in part *c*. Your estimated supply equation for rutabagas is:

$$\hat{Q}_s = \_\_\_\_\_.$$

Are the estimated parameters statistically significant at the 10 percent level? At the 5 percent level?

i. You expect ARGA (the American Rutabaga Growers Association) to spend $75,000 (inflation adjusted) on advertising in 2006. Meteorological forecasts indicate the weather index for 2006 is likely to be 118.5. Forecast the market price and market output of rutabagas for 2006.

Multiple Choice / True-False

1. If the demand curve is stable and the supply curve is shifting, estimation of $Q = a + bP$ will result in estimation of
   a. demand.
   b. supply.
   c. neither demand nor supply.
   d. both demand and supply.

2. In the following demand-supply system

$$\textit{Demand}: \quad Q = a + bP + cM$$

$$\textit{Supply}: \quad Q = d + eP + fP_L$$

   a. neither of the equations are identified.
   b. the demand function is identified but the supply function is not.
   c. the supply function is identified but the demand function is not.
   d. both equations are identified.

3. An identification problem will arise when
   a. the demand function is specified to be linear.
   b. the demand function includes too many exogenous variables.
   c. sample observations are the result of simultaneous interaction of supply and demand.
   d. the firm is a price-setting firm.

4. Two-stage least-squares estimation
   a. can only be used to estimate the parameters of an identified equation.
   b. eliminates the need to identify demand.
   c. produces parameter estimates that can be tested for statistical significance using the usual *t*-test or *p*-values.
   d. both *a* and *c*.
   e. both *b* and *c*.

In questions 5–10, the following nonlinear demand function is estimated using 2SLS:

$$Q = aP^{b}M^{c}P_{y}^{d}$$

The estimation results are:

Two-Stage Least-Squares Estimation

DEPENDENT VARIABLE: LNQ

OBSERVATIONS: 44

VARIABLE	PARAMETER ESTIMATE	STANDARD ERROR	T-RATIO	P-VALUE
INTERCEPT	–2.00	0.40	–5.00	0.0001
LNP	–1.10	0.44	–2.50	0.0166
LNM	2.40	0.60	4.00	0.0003
LNPR	–0.20	0.05	–4.00	0.0003

5. Which of the following supply equations result in the demand equation being identified?
   a. $Q = eP + f\,M + g\,P_y$
   b. $Q = eP + f\,M + gP_y + h\,Z$
   c. $\ln Q = \ln e + f \ln P + g \ln W$
   d. both *b* and *c*

6. These estimates indicate that the demand for the good is
   a. price inelastic since $\hat{E} = -1.10$.
   b. price elastic since $\hat{E} = -1.10$.
   c. price inelastic since $\hat{E} = -2.5$.
   d. price elastic since $\hat{E} = -2.5$.

7. The estimated own price elasticity of demand is
   a. statistically significant at the 5 percent significance level since $*-2.5* > 2.021$.
   b. *not* statistically significant at the 5 percent significance level since $0.004 < 2.021$.
   c. statistically significant at the 5 percent significance level since $*-2.5* > 2.000$.
   d. *not* statistically significant at the 5 percent significance level since $2.6 < 2.721$.

8. The estimates indicate that the income elasticity of demand is
   a. −0.20.
   b. −2.0.
   c. 2.4.
   d. 4.0.

9. The estimate of the cross-price elasticity indicates that the two goods are
   a. normal goods.
   b. substitute goods.
   c. inferior goods.
   d. complementary goods.
   e. none of the above.

10. According to the estimated demand equation, if the price of *Y* rises by 25 percent, then quantity demanded will
    a. increase by 5 percent.
    b. decrease by 5 percent.
    c. increase by 6 percent.
    d. decrease by 6 percent.

11. From the above estimates, we would expect quantity demanded to rise by 30 percent if income
    a. rises by 12.5 percent.
    b. rises by 8 percent.
    c. falls by 0.08 percent.
    d. falls by 125 percent.

12. Why can we estimate the demand for a price-setting firm using ordinary least-squares whereas estimating market demand requires the two-stage least-squares method?
    a. For a firm, there are always exogenous variables in supply but not demand.
    b. For a firm, there are always exogenous variables in demand but not supply.
    c. The manager of the firm sets the price, so there is no simultaneity problem.
    d. both *a* and *c*.
    e. both *b* and *c*.

13. A market-determined price
    a. is determined by the manager of a firm.
    b. is determined by the intersection of demand and supply curves.
    c. is an endogenous variable.
    d. both *a* and *b*.
    e. both *b* and *c*.

14. Manager-determined prices are
    a. not determined by the forces of demand and supply.
    b. exogenous variables in a demand equations.
    c. associated with price-taking firms.
    d. both *a* and *b*.
    e. both *b* and *c*.

15. When price is endogenously determined
    a. two-stage least-squares (2SLS) estimation of parameters is appropriate.
    b. ordinary least-squares (OLS) estimation of parameters is appropriate.
    c. the problem of simultaneity arises.
    d. both *a* and *c*.
    e. both *b* and *c*.

In questions 16–18, use the following estimates of the market supply and demand functions:

Demand: $Q_d = 16{,}000 - 20{,}000P + 4M$

Supply: $Q_s = 80{,}000 + 15{,}000P - 7{,}000P_1$

From a macroeconomic forecast, the predicted values for M and P_I in 2009 are:
$\hat{M}_{2009} = 16{,}000$ and $\hat{P}_{I,2009} = 10$.

16. What is your price forecast for 2009?
    a. $1
    b. $2
    c. $3
    d. $4
    e. $5

17. What is your sales forecast for 2009?
    a. 10,000 units
    b. 20,000 units
    c. 30,000 units
    d. 40,000 units
    e. 50,000 units

18. If the 2009 forecast for P_1 had been 5, what would be your sales forecast for 2009?
    a. 60,000 units
    b. 70,000 units
    c. 80,000 units
    d. 90,000 units
    e. 100,000 units

19. T F In a simultaneous equations model containing a supply and a demand equation, both equations are identified if each one contains at least one exogenous variable that is not in the other equation.

20. T F Two-stage least-squares estimation cannot be used to estimate demand unless both supply and demand are identified.

Answers

MATCHING DEFINITIONS

1. endogenous variable
2. exogenous variable
3. ordinary least-squares (OLS)
4. simultaneity problem
5. reduced-form equation
6. identification of demand
7. two-stage least-squares (2SLS)
8. simultaneous equations bias
9. econometric models

STUDY PROBLEMS

1. 2SLS is required when the firm is a price-taking firm because price is determined by the intersection of demand and supply curves. Since P is an endogenous variable, the problem of simultaneity arises. 2SLS eliminates the bias that would occur if OLS were used in this situation.

2. a. No. The demand equation is not identified.

   b. No. Identification of demand requires the supply equation to contain at least one exogenous variable not included in the demand equation. In this case, the demand equation contains an exogenous variable not included in the supply equation.

   c. Yes. Now supply contains an exogenous variable not included in the demand equation.

3. a. Yes, Q should be inversely related to P along a demand curve.

   b. Inferior. Since $\hat{c}$ is negative, X is an inferior good.

   c. Substitutes. Since $\hat{d}$ (= $)Q/)P$) is positive, goods X and R must be substitutes.

   d. The critical value of t for n ! k = 275 – 4 = 271 degrees of freedom and the 5 percent level of significance is (approximately) 1.96. Since $*t*$ > 1.96 for all four t-ratios, all four parameters are statistically significant. Also, the p-values are all smaller than 0.05, which indicates exact levels of significance smaller than 5%.

   e. $\hat{Q}$ = 8,942 at P = 20, M = 50,000, P_R = 100

      (i) $\hat{E}$ = –0.028 [= –12.35 H (20/8,942)]

      (ii) $\hat{E}_{XR}$ = 0.056 [= 5.05 H (100/8,942)]

      (iii) $\hat{E}_M$ = –0.091 [= –0.0163 H (50,000/8,942)]

4. a. Yes. We would expect quantity demanded to be inversely related to the price of housing and mortgage interest rates, and directly related to income and the price of apartments. We would expect the quantity supplied to be directly related to the price of housing and inversely related to the price of building materials.

   b and *c*.

   Step 1: Estimates of supply and demand are already done for you.

   Step 2: Demand:

$$\hat{Q}_H = 504{,}500 - 10.0P_H + 5(52{,}000) + 500(400) - 11{,}750(14)$$
$$= 800{,}000 - 10.0P_H$$

Supply:

$$\hat{Q}_H = 326{,}000 + 15P_H - 1{,}800(320)$$
$$= -250{,}000 + 15P_H$$

Step 3: Find the intersection of supply and demand.

$$800{,}000 - 10P_H = -250{,}000 + 15P_H$$
$$1{,}050{,}000 = 25P_H$$
$$42{,}000 = P_H$$

and

$$Q_H = 800{,}000 - 10(42{,}000) = 380{,}000$$

So, P_{2009I} = \$42,000 and Q_{2009I} = 380,000 new homes per quarter

COMPUTER PROBLEM

a. For the variables provided in the dataset, the most appropriate linear specification of demand is $Q_d = a + bP + cA$.

b. Since rutabaga prices are determined by market forces of demand and supply, the demand for rutabagas should be estimated using 2SLS.

c. $Q_s = d + eP + fW$

d. $\hat{Q}_d = 1{,}378{,}514 - 105{,}420P + 85.5049A$

The two-stage least-squares computer printout looks like this:

Two-Stage Least-Squares Estimation

DEP. VARIABLE: Q

OBS: 21

VARIABLE	PARAMETER ESTIMATE	STD. ERROR	T-RATIO	P-VALUE
INTERCEPT	1378514	1179956	1.17	0.2579
P	–105420	59748.1	–1.76	0.0946
A	85.5049	29.9106	2.86	0.0104

Both slope parameter estimates, $\hat{b}$ and $\hat{c}$, are statistically significant at the 10 percent level (see the *p*-values in the printout above).

e. Use your software program to compute sample means for *Q*, *P*, and *A*. (You will need the sample mean of *A* in part *f*.) The sample mean values $\overline{Q}$, $\overline{P}$, and $\overline{A}$ are, respectively, 5,335,000, 11.562, and 60,532. The estimated price elasticity of demand for rutabagas is computed as follows:

$$\hat{E} = \hat{b}\frac{\overline{P}}{\overline{Q}} = -105420\frac{11.562}{5335000} = -0.2285$$

So, rutabaga demand is estimated to be inelastic. The price of rutabagas must fall by approximately 21.88 percent in order for sales of rutabagas to increase by 5 percent:

$$-0.2285 = \frac{+5\%}{\%\Delta P} \quad \Rightarrow \quad \%\Delta P = -21.88\%$$

f. The estimated advertising elasticity of demand for rutabagas is computed as follows:

$$\hat{E}_A = \hat{c}\frac{\overline{A}}{\overline{Q}} = 85.5046\,\frac{60532}{5335000} = 0.970$$

Rutabaga advertising must increase by approximately 5.15 percent in order for sales of rutabagas to increase by 5 percent:

$$0.970 = \frac{+5\%}{\%\Delta A} \quad \Rightarrow \quad \%\Delta A = 5.15\%$$

g. Since rutabaga prices are determined by market forces of demand and supply, the supply for rutabagas should be estimated using 2SLS.

h. Your estimated supply equation is $\hat{Q}_s = -2,562,672 + 87,214.0P + 60,605.7W$, which comes from the following 2SLS regression printout:

Two-Stage Least-Squares Estimation

DEP. VARIABLE: Q

OBS: 21

VARIABLE	PARAMETER ESTIMATE	STD. ERROR	T-RATIO	P-VALUE
INTERCEPT	–2562672	1413288	–1.81	0.0865
P	87214.0	12119.5	7.20	0.0000
W	60605.7	11770.9	5.15	0.0001

All parameter estimates are statistically significant at the 10 percent level of significance, but only the parameter estimates $\hat{e}$ and $\hat{f}$ are statistically significant at the 5 percent level of significance.

i. The demand and supply functions for rutabagas in 2009 are forecasted to be:

$$D: \quad \hat{Q}_{d,2009} = 7,791,014 - 105,420P = (1,378,514 + 85.5 \times 75,000) - 105,420P$$

$$S: \quad \hat{Q}_{s,2009} = 4,619,103 + 87,214P = (-2,562,672 + 60,605.7 \times 118.5) + 87,214P$$

Setting the two forecasted equations for 2009 equal to each other, the forecasted price of rutabagas is found to be 16.466 cents per pound. Then substituting this forecasted price into either the forecasted demand or supply equation gives the forecasted quantity in 2009 as 6,055,169 pounds.

MULTIPLE CHOICE / TRUE-FALSE

1. a As supply shifts along a stable demand, the movement of supply traces out the demand curve.
2. d Demand and supply are both identified. Supply contains P_L, which is not in demand; so demand is identified. Demand contains M, which is not in supply; so supply is identified.
3. c Since sample observations only reveal where demand and supply intersect, it may not be possible to determine the shape of either the demand or supply curve that generated the points in the sample.
4. d 2SLS only works on identified demand equations and the usual test procedure using t-ratios or p-values is used to test for statistical significance.

5. d Both equations *b* and *c* include exogenous variables (*Z* and *W*, respectively) that are not in the demand equation.

6. b Demand is elastic because $\hat{E} = \hat{b} = -1.10$ and $|-1.10| > 1$.

7. a $\left|t_{\hat{b}}\right| = 1.10/0.44 = 2.5 > 2.021$ $(= t_{\text{critical}})$

8. c $\hat{E}_M = \hat{c} = 2.4$

9. d $\hat{E}_{XY} = \hat{d} = -0.20 < 0 \Psi$ *X* and *Y* are complements

10. b $\%\Delta Q / \%\Delta P_Y = -0.20 \Rightarrow \%\Delta Q / +25\% = -0.20 \Rightarrow \%\Delta Q = -5\%$

11. a $\%\Delta Q / \%\Delta M = 2.4 \Rightarrow 30\% / \%\Delta M = 2.4 \Rightarrow \%\Delta M = +12.5\%$

12. c When managers set the price of the firm's product, price is not correlated with the random error term in the firm's demand equation, and OLS is appropriate. If price is determined by the simultaneous interaction of both demand and supply equations, then price will be correlated with the random error term, which creates simultaneous equations bias. This bias can be eliminated by using 2SLS.

13. e Variables whose values are determined by a system of equations are called "endogenous" to that system. Market-determined prices are just such variables.

14. d Manager-determined prices are determined not by a system of demand and supply equations, but by the manager. Thus, such prices are exogenous variables in a demand (or supply) equation.

15. d When a variable is endogenous, its value is determined by all of the exogenous variables in all of the equations, which creates the simultaneity problem. The associated simultaneous equations bias is managed by estimating the equations of the system using the method of two-stage least-squares.

16. b $16{,}000 - 20{,}000P + 4 \times 16{,}000 = 80{,}000 + 15{,}000P - 7{,}000 \times 10 \Rightarrow \hat{P}_{2009} = \$2$

17. d $\hat{Q}_{2009} = 80{,}000 - 20{,}000 \times 2 = 40{,}000$ units or $\hat{Q}_{2009} = 10{,}000 + 15{,}000 \times 2 = 40{,}000$ units

18. a Supply when $P_I = 5$ is $Q = 45{,}000 + 15{,}000P$. Set quantity demanded equal to quantity supplied and solve for $P = \$1$. Substituting $P = 1$ into either demand or supply gives the forecast $\hat{Q}_{2006} = 45{,}000 + 15{,}000(1) = 60{,}000$.

19. T Since both equations include an exogenous variable not in the other equation, then each equation is identified because the *other* equation contains an omitted exogenous variable.

20. F 2SLS can be used to estimate demand as long as demand is identified. The identification status of supply is irrelevant, *unless* you wish to estimate supply.

Homework Exercises

1. The empirical demand for coal world wide (Q_c = tons per day) is specified to be a linear function of the price of coal (P_c = dollars per ton), the average per capital income in the six largest industrial nations (M = dollars per capita), and the price of crude oil (P_o = dollars per barrel):

   World Demand for Coal: $Q_c = a + bP_c + cM + dP_o$

   a. Specify a linear supply equation that will cause the coal demand function to be identified:
   World Supply of Coal: Q_c = _____.

   Because coal prices are market determined, the empirical demand function for coal is estimated using the 2SLS estimation procedure, which produces the following computer printout:

Two-Stage Least-Squares Estimation

DEPENDENT VARIABLE: QC

OBSERVATIONS: 64

VARIABLE	PARAMETER ESTIMATE	STANDARD ERROR	T-RATIO	P-VALUE
INTERCEPT	1150000.0	253800	4.53	0.0001
PC	–15508.0	3953.0	–3.92	0.0024
M	37.20	9.55	3.90	0.0003
PO	56034.0	14524	3.86	0.0003

   b. The sign of $\hat{b}$ _____ (is, is not) as would be predicted theoretically.

   c. At the 1 percent level of significance, the critical value of the t-statistics is _____.

   d. Are the parameter estimates $\hat{a}, \hat{b}, \hat{c}$, and $\hat{d}$ statistically significant at the 1 percent level of significance?
   $\hat{a}$: _____ (significant, NOT significant)
   $\hat{b}$: _____ (significant, NOT significant)
   $\hat{c}$: _____ (significant, NOT significant)
   $\hat{d}$: _____ (significant, NOT significant)

   e. If the price of coal is $26.50 per ton, income per capita is $19,245, and the price of a barrel of crude oil is $18.50, calculate quantity demanded of coal worldwide:
   $\hat{Q}_c$ = _____ tons of coal per day.
   Show your work here:

f. For the values given in part *e*, estimate the elasticities of demand for coal:

(i) Price elasticity $\hat{E}$ = _____.

(ii) Income elasticity $\hat{E}_M$ = _____.

(iii) Cross price elasticity $\hat{E}_{co}$ = _____.

Show your work here:

g. Using the elasticities estimated in part *f*, calculate the impact on coal consumption if

(i) The formation of a coal cartel increases coal prices by 20 percent.

$\%\Delta Q_c$ = _____

(i) A worldwide economic recovery increases average per capita income in the six largest industrialized nations by 6 percent.

$\%\Delta Q_c$ = _____

(ii) Hostilities in the Middle East close the Persian Gulf to shipping causing crude oil prices to rise by 16 percent.

$\%\Delta Q_c$ = _____

Show your work here:

2. A coal-market analyst at Meryl-Long, Inc. estimated the market demand and supply functions for coal in 2007 and obtained the following results:

Demand: $Q = 2{,}500 - 2.6P + 0.005M + 16.2P_R$

Supply: $Q = 200 + 48P - 4P_I$

where Q = quantity of coal (tons per day), P = real price of coal ($/ton), M = income per capita, P_R = real price of oil ($/100-barrel contract), and P_I = coal miners' wage rate ($/hour). M-L, Inc. forecasts the values of the exogenous variables in 2008 as follows: M = $40,000, P_R = $1,500, and P_I = $24.

a. For 2008, the forecasted real price of coal is $_____ per ton.

b. The forecasted quantity of coal production in 2008 is _____tons per day.

c. A rival consulting firm disagrees with M-L's forecast for the real price of oil. The rival's forecast is $2,600 per 100 barrels based on the belief that OPEC is likely to restrict crude oil supply in 2008. If P_R does indeed turn out to be

$2,600 in 2008, while the forecasted values for M and P_I match precisely M-L's forecasts, the new price and output forecasts for 2008 are P_{coal} = $_____ per ton and Q_{coal} = _____ tons per day.

d. The forecast of the coal miners' wage rate for 2008 depends on the new union contract that will be negotiated in 2008. If the UMW (United Mine Workers) union manages to win additional concessions that increase the wage rate (P_I) to $30 (instead of $24), while the forecasted values of M and P_R are unchanged (M = $40,000, P_R = $975), the new price and output forecasts for 2008 are P_{coal} = $_____ per ton and Q_{coal} = _____ tons per day. *Show your work below.*