**Chapter 3**

***Empirical Methods for Demand Analysis***

**SOLUTIONS TO END-OF-CHAPTER QUESTIONS**

***ELASTICITY***

1.1 Elasticity of demand for prenatal smoking is inelastic:

ε  %ΔQ/%ΔP

 2.65/21

 0.1262.

1.2 An arc price elasticity is an elasticity that uses the average price and average quantity as the denominator for percentage calculations. For example, let  be the average quantity and  be the average price. The arc price elasticity is

ε = 

ε = .

The change in price is $0.30, and the change in quantity is –2,994. Average price is $1.14, and average quantity is 21,189. Thus, the arc elasticity of demand is

ε =  = –0.537.

1.3 The elasticity of demand is the percentage change in quantity divided by the percentage change in price:

ε = 

ε = .

From the demand equation,  is –2, so

ε = .

ε = –0.250.

1.4 The elasticity of demand is the percentage change in quantity divided by the percentage change in price:

ε = 

ε = .

From the demand equation,

 =  ,

so

ε = 

ε = .

Since Q = , substituting this for *Q* in the equation for elasticity above,

ε = –0.504.

1.5 The elasticity of demand is the percentage change in quantity divided by the percentage change in price:

ε = 

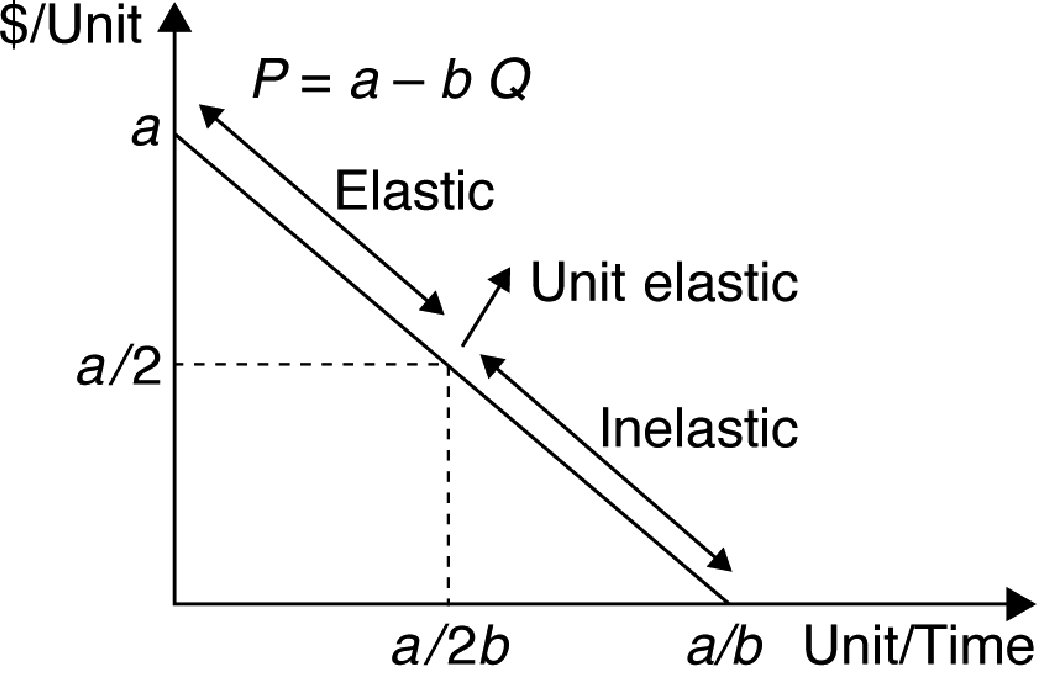
ε = .

From the demand equation,  is –4*p* = –4(10) = –40, so

ε = .

ε = –0.500.

1.6 The figure below refers to the graph of a linear inverse demand curve. Demand is elastic for all quantities to the left of the midpoint. At the midpoint, elasticity equals –1. Finally, demand is inelastic for all quantities to the right of the midpoint.



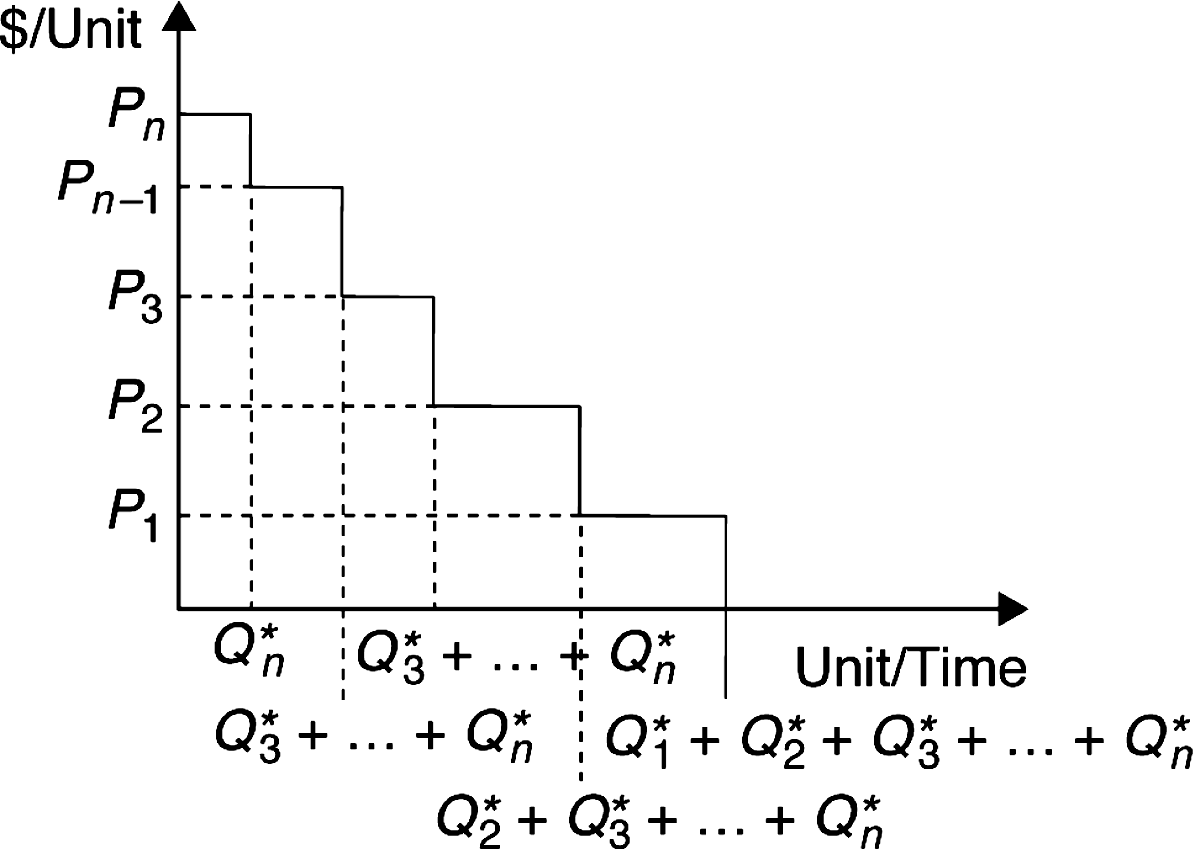
1.7 According to Equation 3.1, the elasticity of demand is *ε*  (percentage change in quantity demanded ÷ percentage change in price)  3.8% ÷ 10%  0.38, which is inelastic.

1.8 Suppose there are *n* countries in the world. Assume the choke prices for countries are  ⋅ ⋅ ⋅and the corresponding quantities are The demand function, *Qi*, for each country is as follows:



The world demand function is the horizontal sum of demand in each country. The world demand function, *Q* in this case, will be a step function:





As *n* (the number of countries) increases, the world demand curve gets closer to a linear demand curve. Like a linear demand curve, the world demand becomes more inelastic as you move down along the inverse demand curve.

1.9 The price elasticity of demand is the percentage change in quantity divided by the percentage change in price:

ε = 

ε = .

From the demand equation,  is –9.5. So, the price elasticity of demand is

ε = 

ε = 0.335.

Calculated similarly,  is 16.2, so the cross-price elasticity of demand with respect to the price of palm oil is

ε = 

ε = 0.394.

1.10 The income elasticity of demand is the percentage change in quantity divided by the percentage change in income:

ε = 

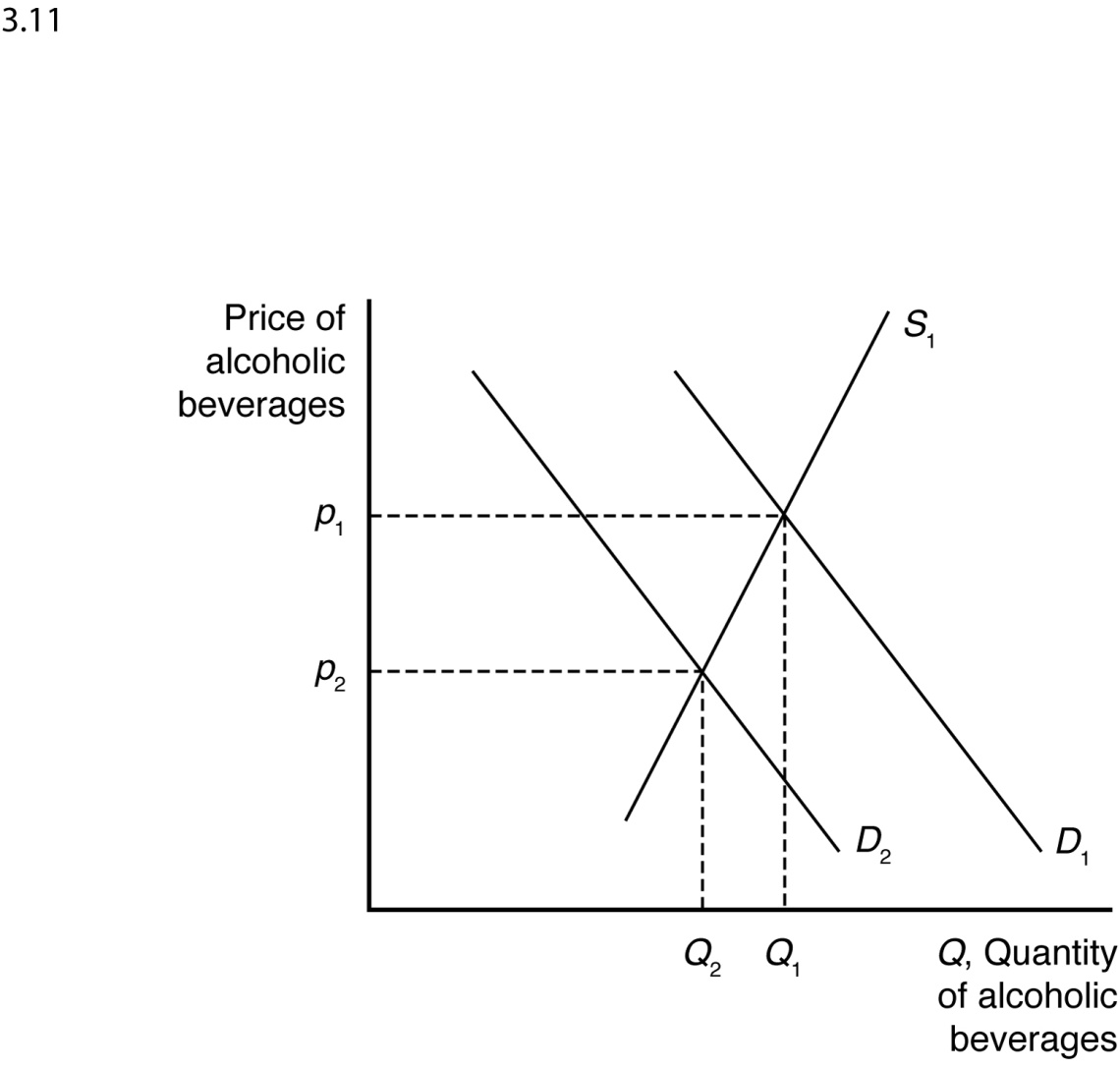
ε = .

From the demand equation,  is 0.2. Plugging in 45 cents for *p,* 31 cents for *pp,* and 1,275 for *Q* and then solving for *Y, Y* = $1.5. So, the income elasticity of demand is

ε = 

ε = 0.0002.

1.11 The connection between these two events is the complementary relationship between smoking and alcohol consumption discussed in the Mini-Case. As mentioned there, the value of the cross-price elasticity between cigarettes and alcoholic beverages is roughly –1.0. When a tax is placed on cigarettes, this shifts the supply curve left (assuming the producers remit the tax, although the same result occurs if buyers do so) and drives up the equilibrium price of cigarettes. As the price of cigarettes rises, the demand for alcoholic beverages falls. This results in a smaller equilibrium quantity in the market for alcoholic beverages as shown in the figure below.

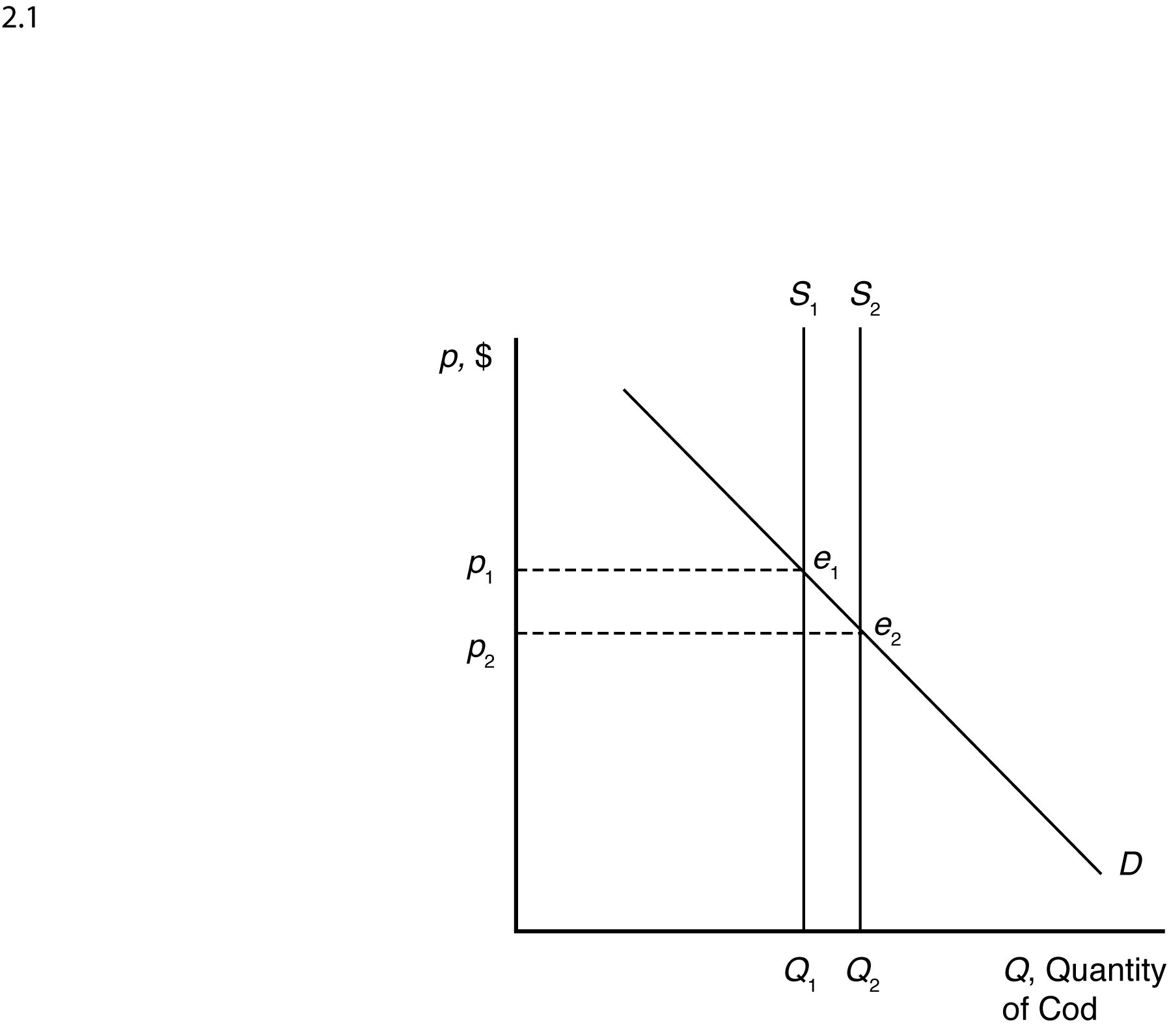


1.12 The Mini-Case describes a good, Google Play apps, with very elastic demand (estimated coefficient of –3.7). If the price of these apps increases by 5% then the quantity demanded will fall (as evidenced by the negative sign) by 5 × 3.7 = 18.5%. Revenue in this case will fall. To calculate the percentage change in revenue, consider first the amount of revenue the firm earns before the price change (*R*1 = *P* × *Q*) and compare to the revenue earned after the price change, which is given by *R*2 = *P*(1 + 0.05) × *Q*(1 – 0.185) = *PQ* × 0.88575 = *R*1 × 0.88575. This means that revenue falls by roughly 14% as a result of this price change.

***REGRESSION ANALYSIS***

2.1 Assume the first day, the supply of cod is *S*1. The next day, the supply of cod is *S*2. A market equilibrium occurs where supply equals demand. In this case, the equilibrium is where the vertical supply curve intersects the downward-sloping demand curve.

The demand curve shows the quantity demanded at various prices. The demand curve is identified from frequent changes in supply because the demand curve is assumed not to shift from day to day. As a result, each market equilibrium price and quantity of cod reveals a point along the demand curve.



2.2 A demand function with price as the only explanatory variable defines a demand curve:

*Q* = *a* + *bp*.

Quantity is a function of price in a demand function, while price is a function of quantity in an inverse demand function. We can use algebra to rearrange a linear demand equation so that price is on the left side and quantity on the right side to generate the inverse demand curve:

*p* = –(*a*/*b)* + (1/*b*)*Q*.

Asking how many customers would buy a proposed new menu item at various prices can be used to estimate the demand curve, and the inverse demand curve can be calculated from it.

A demand function with price and income as explanatory variables can be generated from the focus group by also asking for their level of income. Essentially, a regression with the quantity demanded as the dependent variable and price and income as the explanatory variables could be estimated if each member of the focus group is asked their level of income.

2.3 If *p* = $2.00, then the predicted quantity is

*Q* = 130 – 3.5*p*

*Q* = 130 – 3.5(2.00)

*Q* = 130 – 7

Q = 123 units.

In this case, the residual would be the difference in the predicted quantity and the actual quantity

129 – 123 = 6.

Included in the error term is any factor that would affect the quantity of popsicles demanded but that is not directly included in the demand equation. Factors that affect the demand for popsicles include consumer income, the prices of substitutes and complements, the weather, and temperature.

2.4 A demand function with price as the only explanatory variable defines a demand curve:

*Q* = *a* + *bp*.

Quantity is a function of price in a demand function. Using Excel, the equation for this demand function is

*Q* = 92.429 – 0.6857*p*.

The *R*2 statistic is the share of the dependent variable’s variation that is “explained by the regression”—that is, accounted for by the explanatory variables in the estimated regression equation. Using Excel, the statistic is 0.9749.

***PROPERTIES AND STATISTICAL SIGNIFICANCE OF ESTIMATED COEFFICIENTS***

3.1 Using Excel, the equation for this demand function is

*Q* = 12.533 – 6.2496*p*.

3.2 This question has multiple parts. Each part is answered below.

1. Using Excel, the equation for the demand function with 2.0 as the quantity in the first row is

*Q* = 12.140 – 5.8546*p*.

1. Using Excel, the equation for the demand function with 2.7 as the quantity in the second row is

*Q* = 12.493 – 6.1545p.

3.3 From the demand equation,  is –1.438, so the effect of an increase in price on the quantity of Camry’s demanded is

ΔQ = –1.438(Δp)

ΔQ = –1.438(1)

ΔQ = –1.438 thousand.

From the demand equation, if the price is $20 thousand, then demand is

Q = 53.857–1.438p

Q = 53.857–1.438(20)

Q = 25.097 thousand

The elasticity of demand is the percentage change in quantity divided by the percentage change in price:

ε = 

ε = .

From the demand equation,  is –1.438, so

ε = .

ε = –1.146.

3.4 According to Excel, the price coefficient’s standard error is 0.0549, and the corresponding t-statistic is –12.477. Statistically, an explanatory variable’s coefficient is significantly different than zero at the 0.05 level if its *t*-statistic is larger than 1.96 in absolute value. In this example, the *t*-statistic is 12.477, so the price coefficient is statistically significant.

***REGRESSION SPECIFICATION***

4.1 An explanatory variable’s coefficient is statistically significantly different than zero at the 0.05 level if its *t*-statistic is larger than 1.96 in absolute value. In this example, the *t*-statistic is 4.25, so the price coefficient is statistically significant.

A year of experience raises CEO compensation by 36.10 thousand dollars, which seems economically significant.

4.2 To find the log-linear demand equation, take the log of both sides and simplify:

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You can estimate this in Excel using an OLS regression of the form



by converting your quantity and price data to logs. In the resulting regression, α will be an estimate of ln(*A*), and β will be an estimate of ε.

4.3 Revenue (*R*) is defined as the price of the good (*p*) multiplied by the quantity of the good sold (*Q*):

*R* = *pQ*.

As such, revenue is not linear in price, so using the linear function form would be a misspecification. Because the relationship between price and quantity is linear, the linear functional form could be used to estimate quantity with price as an explanatory variable.

***FORECASTING***

5.1 Fresh foods are substitutes for Heinz prepared foods. Because fresh fruits and vegetables are in greater supply in May, June, and July, and their corresponding prices are likely lower, consumers demand less of Heinz prepared foods, decreasing Heinz’s second-quarter revenues.

5.2 The estimated relationship on the second quarter explanatory variable is 0.482, indicating a positive relationship between revenue and the second quarter. The key to understanding the comparison to other quarter is to note that the missing quarter is *D*4. That means that the coefficient for each of the other quarterly dummy variables measures the difference relative to *D*4. So, the 0.482 means that revenue is $482 million higher in quarter 2 than quarter 4. Furthermore, the second quarter has higher revenue than the first quarter but lower revenue than the third quarter.

5.3 Revenue is determined in large part by the consumers’ demand curve. We know that consumer demand is affected by variables such as income, population, and advertising. Forecasts based on extrapolation (pure time series analysis) ignores these structural, causal variables. The role of such variables may be implicit in an extrapolation. For example, one reason why revenue may have grown smoothly over time is that population increased smoothly over this period. An alternative to extrapolation uses economic theory to derive the causal relationships between economic variables. Forecasts based on a regression specification that incorporates underlying causal factors is called theory-based econometric forecasting. With theory-based econometric forecasting, we predict the dependent variable based on underlying factors, not just on the time-series pattern of the dependent variable. We need theory-based methods to forecast revenues for companies such as FedEx and Sony because demand for their products is affected by structural variables and does not smoothly follow a time trend.

***MANAGERIAL PROBLEM***

6.1 This question has multiple parts. Each part is answered below.

1. A *t*-statistic equals the coefficient divided by the standard error, so the standard error equals the coefficient divided by the *t*-statistic: –413/–12.8 = 32.266.
2. The new standard error would be 322.66. An explanatory variable’s coefficient is statistically significantly different than zero at the 0.05 level if its *t*-statistic is larger than 1.96 in absolute value. In this example, the *t*-statistic is –1.28, from –413/322.66, so the price coefficient is not statistically significant.

6.2 Using Excel, the equation for this demand function is

*Q* = 1,023.92 – 412.82p.

The statistic is the share of the dependent variable's variation that is “explained by the regression”—that is, accounted for by the explanatory variables in the estimated regression equation. Using Excel, the statistic is 0.960.

The standard error is a measure of how much each estimated coefficient would vary if we re-estimated the underlying true demand relation with many different random samples of observations. The standard error on the intercept is 33.78, and the standard error on the price coefficient is 32.70.

A *t*-statistic for a regression variable can be calculated as the estimated coefficient divided by the coefficient’s standard error. For the intercept, this is 30.311, from a coefficient of 1,023.92 divided by 33.78. For the price variable, this is –12.624, from –412.82 divided by 32.70.

An explanatory variable’s coefficient is statistically significantly different than zero at the 0.05 level if its *t*-statistic is larger than 1.96 in absolute value. In this example, the *t*-statistic for the intercept is 30.311, so statistically it is significantly different than zero. The t-statistic for the price variable is 012.624, so it is statistically significantly different than zero.

***SOLUTIONS TO SPREADSHEET EXERCISES***

See the associated Excel files.