Answers to Chapter 4 Exercises

Review and practice exercises

■ 4.1. Vitamin C. Vitamin C is a generic vitamin that is produced by many companies: brand names are not very important, entry is easy. A good friend — a world-renowned orthopedic surgeon from New Jersey — tells you that he is about to publish in *The New England Journal of Medicine* (a highly respected and widely quoted medical journal) a study indicating that daily doses of 500 mg of vitamin C tends to improve the muscle tone and increase the physical stamina of adults, with no adverse side effects. Though a very good doctor, he is woefully ignorant about the basic workings of markets and wants to know what is likely to happen, and why — in the short run and in the long run — to the price of vitamin C, to the quantity sold, to the profits of the producers, and to the number of firms that produce it. Summarize what you would tell him.

**Answer:** One would expect demand to increase as a result of the NEJM article. In the short-run, supply is fixed. We would therefore observe a move along the supply curve, with both price and output going up. The extent of the price hike would depend on the steepness of the supply curve: the steeper the short-run supply curve is, the greater the price increase.

In the long-run, one would expect the supply function to expand, as new producers enter the market and existing producers expand their capacity. Assuming that demand is kept at the same level, this would correspond to a movement along the demand curve, with output going up and price going down.

To summarize: We would expect price to go up in the short-run, then back down in the long-run, possibly to almost the same level as the initial level. As to output, we would expect it to go up, with a greater increase in the long-run than in the short run.

■ 4.2. Comparative statics: aspartame, oil. For each of the following, use a supply and demand diagram to deduce the impact of the event on the stated market. Would you expect the impact to be primarily on price or quantity? Feel free to mention issues that you don’t think are captured by a traditional supply and demand analysis.

(a) Event: The FDA announces that aspartame may cause cancer. Market: Saccharin. (Note: aspartame and saccharin are low-calorie sweeteners.)
Answer: Saccharin and aspartame are substitutes. We would expect demand for saccharin to increase (demand curve shifts up/right). This would lead to an increase in the price of saccharin and the quantity produced. The supply is likely to be fairly elastic (flat) as there are several producers. Thus we would expect the main impact to be on quantity. The supply curve is expected to be flat particularly in the long-run. For example, suppliers of other related products can convert their production capacity to saccharin if the price were to remain at high levels for very long.

(b) Event: Oil price increases. Market: California electricity.

Answer: Oil is an input to some of the generating plants. This implies an upward shift in marginal cost of some plants (those that use oil). If the plants are the marginal ones (those determining the price) then price will rise. Since demand is inelastic, the primary impact will be on price. Otherwise, there’s no impact: these plants simply make less money. Some of you may have also noticed that oil and electricity are substitutes (in the long run). This implies that you can also have a shift of the demand to the right. This increases the price even further, and makes the overall effect on quantity ambiguous.

4.3. Comparative statics: price and quantity effects. Consider following events and markets:

- OPEC reduces oil output [market: oil]
- Unusually rainy winter in New York City [market: umbrellas in NYC]
- Champions League final in Madrid [market: Madrid hotels]
- Unusually low catch of sole fish [market: sole fish]

Which of the four corresponds to the four cases considered in Figure 4.3?

Answer:

- Top left: umbrellas
- Top right: Madrid hotels
- Bottom left: sole fish
- Bottom right: oil

4.4. Kidney transplants. Suppose that in a given state — let’s call it state X — a few recent kidney transplant malpractice suits have led to punitive damage awards of unprecedented levels. What impact do you expect this to have in the market for kidney transplant services in state X? To the extent that you can, and making the necessary assumptions as you go along, indicate the expected effects on price and quantity; the relative magnitude of these effects; and any possible differences between short-run and long-run effects.

Answer: The possibility of expensive lawsuits will lead doctors to take on more insurance, and premiums for such insurance will increase. This implies an upward shift in the supply
curve as each doctor now charges more per unit of service. Given a demand curve, this immediately leads to an increase in price and a decrease in quantity. Depending on the nature of demand, the demand elasticity may be greater or smaller in absolute value. As a general rule, demand for medicines and medical services tends to be relatively inelastic. However, while demand for kidney transplants is relatively inelastic, the demand for kidney transplants in state X is probably fairly elastic: one can always travel to a neighboring state. I would thus expect the main effect to be on quantity: state X will likely become a state with very few kidney transplants.

In the longer run, two things will happen. First, to the extent that demand is downward sloping, doctors are now receiving a lower net price per unit of medical services (the rest is insurance premiums). In the long run, doctors will be more flexible regarding their location and it is expected that some will move out of state. This implies a further shift in the supply curve, this time to the left. Second, buyers are also likely to be more flexible, which implies a shift in the demand curve to the left. Both movements imply a decrease in quantity. The effect on price is unclear: the shift in supply leads to an increase in price, whereas the shift in demand leads to a decrease in price.

4.5. Book publishing. The technology of book publishing is characterized by a high fixed cost (typesetting the book) and a very low marginal cost (printing). Prices are set at much higher levels than marginal cost. However, book publishing yields a normal rate of return. Are these facts consistent with profit maximizing behavior by publishers? Which model do you think describes this industry best?

Answer: The model of monopolistic competition is probably the best approximation to describing this industry. The model of monopolistic competition shows that price-making, profit-maximizing behavior is consistent with a zero-profit long-run equilibrium. The strong scale economies in book publishing imply that the gap between price and marginal cost is particularly high.

4.6. Laundry detergent. The market for laundry detergent is monopolistically competitive. Each firm owns one brand, and each brand has effectively differentiated itself so that is has some market power (i.e., faces a downward sloping demand curve). Still, no brand earns economic profits, because entry causes the demand for each brand to shift in until the seller can just break even. All firms have identical cost functions, which are U-shaped.

Suppose that the government does a study on detergents and finds out they are all alike. The public is notified of these findings and suddenly drops allegiance to any brand. What happens to price when this product that was brand-differentiated becomes a commodity? What happens to total sales? What happens to the number of firms in the market?

Answer: Based on the information provided, it seems that the initial situation in this market is like the long-run equilibrium of the monopolistic competition model; see Figure 6.3. The government’s announcement has turned a differentiated product into a homogeneous one. In terms of the graph in Figure 6.3, this implies a flattening of the demand curve faced by each firm and a new long-run equilibrium where $d$ (now horizontal) is tangent to the $AC$ curve. At this new long-run equilibrium, price is given by $p_{LR}'$ and each firm’s output is
Clearly, the new equilibrium implies a lower price and a higher output per firm: \( p_{LR}' < p_{LR} \) and \( q_{LR}' > q_{LR} \).

Suppose that price were to drop from \( p_{LR} \) to \( p_{LR}' \) without changing the degree of product differentiation or the number of firms. This would imply an output per firm equal to \( q_{SR}' \), where \( q_{SR}' \) is greater than \( q_{LR} \) but lower than \( q_{LR}' \). If we take into account the disappearance of product differentiation (and continue with the same number of firms), then the output per firm would be less than \( q_{SR}' \). Whatever the exact value is, each firm would be losing money \( (p_{LR}' < AC) \). Therefore, in the post-announcement long-run equilibrium, some firms will need to exit the market.

Finally, it is not clear what will happen to total output. On the one hand, each firm's output goes up. On the other hand, the number of firms goes down. Which effect dominates depends on how consumers value product differentiation and how the demand curve shifts as a result of the government announcement.

### 4.7. T-shirt printing.

The custom T-shirt printing business has many competitors, so that the perfect competition model may be considered a good approximation. Currently the market demand curve is given by \( Q = 120 - 1.5p \), whereas the market supply is given by \( Q = -20 + 2p \).

(a) Determine the market equilibrium

**Answer:** Equilibrium price is given by the equality

\[
120 - 1.5p = -20 + 2p
\]

which implies \( p = 40 \). Substituting into the demand curve (or the supply curve, it doesn't matter), we get \( Q = 60 \).

Suppose there is a T-shirt craze that increases demand by 10% (that is, for each price, demand is now 10% greater than it was before the price increase).

(b) Determine the new demand curve.

**Answer:** The new demand curve is obtained by multiplying the initial one by \( 1.1 = 1 + 10\% \):

\[
Q = 1.1 \times (120 - 1.5p) = 132 - 1.65p
\]

(c) Determine the change in equilibrium quantity.

**Answer:** Equilibrium price is given by the equality

\[
132 - 1.65p = -20 + 2p
\]

which implies \( p = 41.64 \). Substituting for \( p \) in the demand curve we get \( Q = 63.29 \). Note that the initial value of \( Q \) was 60. We thus have an increase of \( 3.29/60 \), or 5.48%.

(d) If your answer to the previous question is different from 10%, explain the difference in values.
The shift of the demand curve is partly reflected in an increase in $Q$ and partly in an increase in $p$. If the supply curve were flat, then the increase in equilibrium $Q$ would be exactly 10%. Since the supply curve is upward sloping, the increase is less than 10%.

Now go back to the initial demand curve and suppose there is an increase in the cost of blank T-shirts, an essential input into the business of selling custom T-shirts. Specifically, for each unit by each supplier, the production cost goes up by 10%.

(e) Determine the new supply curve.

Answer: Since we have a proportional vertical increase in the supply curve (that is, when the supply curve is expressed in the inverse form with price units as a function of quantity units), we must first find the inverse supply curve, then multiply it by 1.1, then invert it back again to obtain the (direct) supply curve. From $Q = -20 + 2p$ we get

$$p = 10 - .5Q$$

The new inverse supply curve is thus given by

$$p = 1.1 \times (10 + .5Q) = 11 + 5.5Q$$

which can be inverted into

$$Q = -20 + 1.82p$$

(f) Determine the change in equilibrium price.

Answer: The new equilibrium price is given by the equality

$$120 - 1.5p = -20 + 2p$$

which implies $p = 42.17$. This corresponds to an increase of $2.17/40 = 5.42\%$.

(g) If your answer to the previous question is different from 10%, explain the difference in values.

Answer: The answer is similar to that of question (d). If the demand curve where perfectly inelastic, then the shift in the supply curve would imply a change in equilibrium price of exactly 10%. Since the demand curve is downward sloping, the upward shift in the supply curve implies an increase in prices as well as a decrease in equilibrium quantity. For this reason, the increase in equilibrium price is lower than the shift in the supply curve.

4.8. Sales tax. Consider an industry with market demand $Q = 550 - 20p$ and market supply $Q = 100 + 10p$. Determine the equilibrium price and quantity. Suppose the government imposes a tax of $6 per unit to be paid by consumers. What is the impact on equilibrium price and quantity? What if the sales tax is paid by the seller instead of the buyer?

Answer: We derive equilibrium $p$ and $Q$ by solving the supply and demand system of equations. Since both are written in terms of $Q$, this is a relatively easy task:

$$550 - 20p = 100 + 10p$$
or simply
\[ p = \frac{550 - 100}{20 + 10} = 15.6 \]
Substituting for \( p \) in the supply equation, we get
\[ Q = 100 \times 15.6 + 10 = 250 \]
Suppose each consumer must pay a $6 tax. This means each consumer is willing to pay 6 dollars less for each unit then before. Consumer gross willingness to pay is given by the inverse demand curve. From \( Q = 550 - 20p \), we get
\[ p = \frac{550}{20} - \frac{1}{20} \cdot Q = 27.5 - \frac{1}{20} \cdot Q \]
It follows that, with the sales tax, willingness to pay is now given by
\[ p = \left( 27.5 - \frac{1}{20} \cdot Q \right) - 6 = 21.5 - \frac{1}{20} \cdot Q \]
or, to put in the same form as initially,
\[ Q = 430 - 20p \]
The new equilibrium is determined by the intersection of the demand and the new supply curve:
\[ 430 - 20p = 100 + 10p \]
or simply
\[ p = \frac{430 - 100}{20 + 10} = 11 \]
Substituting for \( p \) in the supply equation, we get
\[ Q = 100 \times 11 = 210 \]
Notice that the price effectively paid by consumers is \( 11 + 6 = 17 \). This represents an increase of 2 with respect to the initial price, which is considerably less than 6. Why? because some of the tax's burden is taken by sellers, who now receive a price of 11, a drop of 4. (Note that, as expected, \( 2 + 4 = 6 \), the value of the tax.)

Suppose instead that sellers must pay the $6 tax. This means that if a seller was willing to sell for a price \( p \), it is now willing to sell for \( p + 6 \), so that the net price is the same \( p \) as before. What is then the new supply function? It helps to solve it in terms of \( p \) as a function of \( Q \):
\[ p = -\frac{100}{10} + \frac{1}{10} \cdot Q \]
The new supply curve is therefore given by
\[ p = \left( -10 + \frac{1}{10} \cdot Q \right) + 6 = -4 + \frac{1}{10} \cdot Q \]
or, to put in the same form as initially,
\[ Q = 40 + 10p \]
The new equilibrium is determined by the intersection of the demand and the new supply curve:

\[ 550 - 20p = 40 + 10p \]

or simply

\[ p = \frac{550 - 40}{20 + 10} = 17 \]

Substituting for \( p \) in the supply equation, we get

\[ Q = 40 + 10 \times 17 = 210 \]

As we compare this equilibrium to the case when the tax is paid by the buyer, we realize that: (a) total output is the same; (b) the price effectively paid by the buyer is the same; (c) the price price effectively received by the seller is the same. We have just stumbled into an important result from the economic theory of taxation: the burden of a sales tax does not depend on who actually pays the tax!

Extra credit: What then determines the relative burden of a sales tax that falls on buyers and on sellers?

4.9. Sales tax with steeper demand. Consider again Exercise 4.8. Suppose that demand is instead given by \( Q = 280 - 2p \).

(a) Show that the equilibrium levels of \( p \) and \( q \) are the same as in the initial equilibrium of Exercise 4.8.

Answer: Equilibrium price is determined by

\[ 280 - 2p = 100 + 10p \]

or simply

\[ p = \frac{280 - 100}{2 + 10} = 15 \]

Substituting for \( p \) in the supply equation, we get

\[ Q = 100 + 10 \times 15 = 250 \]

the same values as in the initial equilibrium in Exercise 4.8.

(b) Determine the impact of a $6 sales tax in terms of the price effectively paid by buyers and sellers.

Answer: As shown in Exercise 4.8, it does not matter whether the tax is paid by seller or buyer. Suppose that sellers must pay the $6 tax. As shown in Exercise 4.8, the new supply function is given by

\[ Q = 40 + 10p \]

The new equilibrium is determined by the intersection of the demand and the new supply curve:

\[ 280 - 2p = 40 + 10p \]
or simply
\[ p = \frac{280 - 40}{2 + 10} = 20 \]

Substituting for \( p \) in the supply equation, we get
\[ Q = 40 + 10 \times 20 = 240 \]

(c) Compare the results in (b) to those in Exercise 4.8. Explain the economic intuition.

**Answer:** In Exercise 4.8, a $6 tax lead to an equilibrium price of 17. As a result, the $6 tax is borne by consumers ($2) and firms ($4). By contrast, in the present exercise price is given by 20. As a result, the burden of the $6 tax falls primarily on consumers, who pay $5, whereas firms pay only $1.

The difference between Exercise 4.8 and the present exercise is that demand is now steeper. A steeper demand means that consumers are less sensitive to price changes, which in turn implies that sellers are able to pass through a greater portion of the tax. More generally, the lower the demand elasticity, the greater the incidence of a sales tax on consumers.

### 4.10. Car prices in Europe.

Sales taxes on car purchases in Europe vary from 0% to more than 200%.

The UK is one of the countries with lowest taxes, whereas Denmark is one of the countries with highest taxes.

(a) In which countries do you expect consumer prices to be the highest?

**Answer:** The countries with the highest sales tax.

(b) In which countries do you expect pre-tax consumer prices to be the highest?

**Answer:** The countries with the lowest sales tax.

By law, if a consumer buys a car in country \( x \) and then registers the car in country \( y \), the consumer receives a refund from the tax paid in country \( x \) and then pays the corresponding tax in country \( y \).

(c) What is the optimal car buying strategy for a European who does not mind to purchase abroad?

**Answer:** Purchase the car in the country with the highest sales tax.

### Challenging exercises

### 4.11. Electricity supply.

Consider an electricity market where there are three suppliers, each with constant marginal cost (a reasonable approximation in electricity generation). Firm 1 has a capacity of 200 and \( MC = 5 \). Firm 2 has a capacity of 100 and \( MC = 8 \). Firm 3 has a capacity of 100 and \( MC = 10 \). Suppose that suppliers act as price takers.

(a) Determine the industry supply curve.
Answer: Each firm supplies zero if price is below its marginal cost; if price is greater than marginal cost, then the firm supplies all the way to capacity. It follows that the supply curve is zero for $p$ up to 5, 200 for $p$ in the [5, 8) interval, 300 ($= 200 + 100$) for $p$ in the [8, 10) interval; and 400 ($= 200 + 100 + 100$) for $p$ greater than 10.

(b) Suppose that market demand is given by $Q = 540 - 20p$. Determine the market equilibrium. Is this equilibrium a long-run equilibrium?

Answer: At $p = 10$, demand is $Q = 540 - 200 = 340$. Then Firm 1 produces $q = 200$, Firm 2 produces $q = 100$, and Firm 3 produces $q = 40$. Since the supply curve is such that price equals 10 for any output level between 300 and 400, we confirm that market equilibrium is given by $p = 10$ and $Q = 340$. If the technology available to potential entrants is like firm 3’s, then the answer is yes: an additional entrant would not be able to make positive profits. Notice that, in this equilibrium, while firm 3 earns zero profit (it is the marginal firm), both firms 1 and 2 earn positive profits (rents from a better cost function).

(c) Suppose that (i) demand falls to $D(p) = 400 - 20p$; (ii) Firm 3 reduces its $MC$ to 8; (iii) Firm 2 reduces its $MC$ to 7. What happens to equilibrium profits in each case?

4.12. Average and marginal cost. Show that, in a long-run equilibrium with free entry and equal access to the best available technologies, the comparison of price to the minimum of average cost or the comparison of price to marginal cost are equivalent tests of allocative efficiency. In other words, price is greater than the minimum of average costs if and only if price is greater than marginal cost.

Show, by example, that the same is not true in general (hint: consider a monopolist with constant average and marginal cost).

Answer: We first show the following fact: marginal cost is greater than average cost if and only if average cost is increasing. To see this, notice that Average Cost is given by the ratio Cost / Output. Taking the derivative with respect to Output $q$, we get

$$\frac{dAC}{dq} = \frac{d}{dq} \frac{C}{q} = \frac{dC}{dq} \frac{q - C}{q^2} = \frac{1}{q} (MC - AC)$$

which shows the fact.

In the long-run equilibrium of an industry with equal access, each firm will be producing at a point in the left-hand portion of its Average Cost curve. Given the above fact, it follows that marginal cost is lower than or equal to average cost. Since there is free entry, price is equal to average cost. Specifically, either price is equal to the minimum of average cost and equal to marginal cost; or price is greater than the minimum of average cost and greater than marginal cost.

The same is not true, for example, in a short-run equilibrium. Consider the case of perfect competition. and suppose that price is greater than the minimum of average cost. Since firms are price takers, price is equal to marginal cost. So, the comparison price minus marginal cost is zero whereas price minus the minimum of average cost is positive.
4.13. Market supply. Find firm level data on marginal cost and capacity (e.g., electricity power plants). Estimate the firm and market supply curves under the assumption that firms are price takers.