# Supply and Demand

August 22, 2022

The fundamental model in the field is supply and demand. The model is typically used to predict how equilibrium prices and quantities change when an underlying determinant of supply and/or demand changes. While these models can be used to discuss broad categories of goods (food, energy, etc.), they are best applied to specific goods. While we can draw a supply and demand graph for "food," it is not very useful as there are many different types of food, so the predictions for corn may not be the same as the predictions for peanut butter because there are likely underlying differences in those markets. While peanut butter is a subset of the broad category food, we can still be more specific – chunky or creamy peanut butter. We can be even more specific if we like by getting into brands - Skippy Creamy Peanut Butter. We can get even more specific - a 40 oz. jar of Skippy Creamy Peanut Butter. While the supply and demand principles apply broadly, the more precise you make the good in question, the easier it is to interpret the model.

When creating supply and demand graphs, we hold all other factors constant to focus on the price and quantity of the good. We will examine how other factors affect price and quantity after constructing the model, and later we will discuss how one would theoretically derive these curves.

## 1 Supply

We begin with the Law of Supply:

> There is a direct (positive) relationship between the price of a good and the quantity supplied.

Restating, as the price of a good increases, the quantity supplied will increase, assuming that more can be supplied. You might also hear some people say that supply is upward sloping. These all mean the same thing. We can show this relationship with a graph:

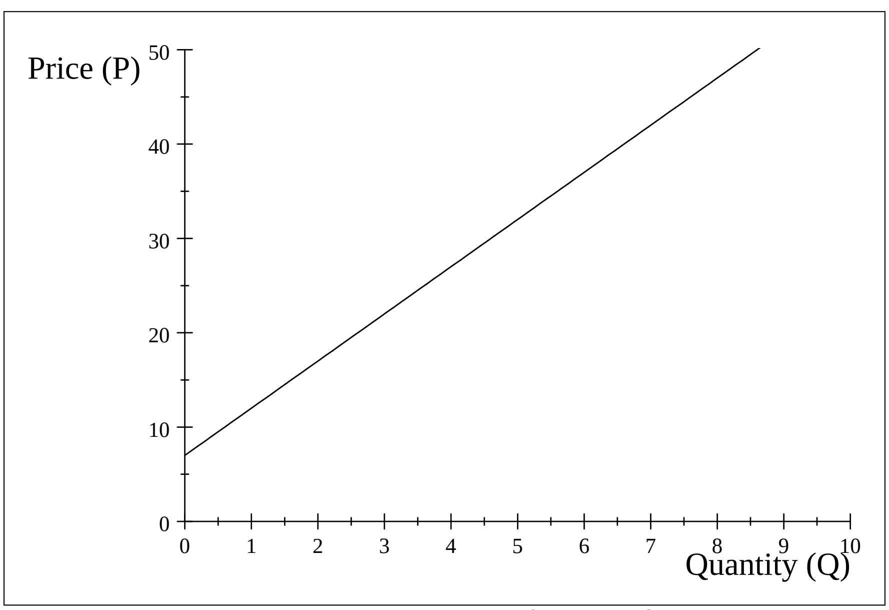


Figure 1: Inverse supply curve for $P = 5Q_S + 7$.

For Figure 1, I have used the linear function $P = 5Q_S + 7$, where $P$ is the price of the good and $Q_S$ is the quantity supplied. Technically, this function is the inverse supply function because we have Price as a function of Quantity Supplied,[1] but the convention in economics is to have Quantity on the horizontal axis and Price on the vertical axis of our graphs, so we tend to use inverse supply and inverse demand functions when creating graphs. We will typically use linear functions in our supply and demand analysis – while the functions can be, and likely are, curved, the intuition to be gained from linear or curved functions is the same. Each point on the curve tells us the quantity supplied at each price.

While we state the "Law of Supply," there are times when this law will be violated. However, it is called a "law" because it generally holds except in some exceptional cases.

## 1.1 Shifts in supply

In the opening it is mentioned that all factors except price and quantity are held constant in this graph. The graph does show how quantity supplied would change if price changes and vice versa. However, what happens if some other factor changes? For instance, what happens if the price of a key resource to produce the good, call it $P_{resource}$, increases? In that case, the entire supply curve will shift.[2] In addition to prices of resources, what other factors could shift the supply curve? Production technology could change, which would typically allow for less expensive production. There could be a tax imposed on the supplier, altering the supplier's costs. For some producers, particularly those of agricultural products, the weather could alter their supply. For any producer, political disruptions could alter supply. A change in the number of firms could alter market supply. These are the major factors that could alter supply.

As an example, suppose that we now have $P = 5Q_S + 3P_{resource} + 1$ as the inverse supply function. We now have three variables (price of the good, quantity supplied, and price of the resource) which we would need to plot in three dimensions. However, looking at three dimensional graphs is not very intuitive for most people. In order to get back to just having price of the good and quantity supplied we replace $P_{resource}$ with its constant value. If we assume that $P_{resource} = 2$, we are then back to our original inverse supply function of $P = 5Q_S + 7$. We can use this process to examine the effect on supply when the price of the resource changes.

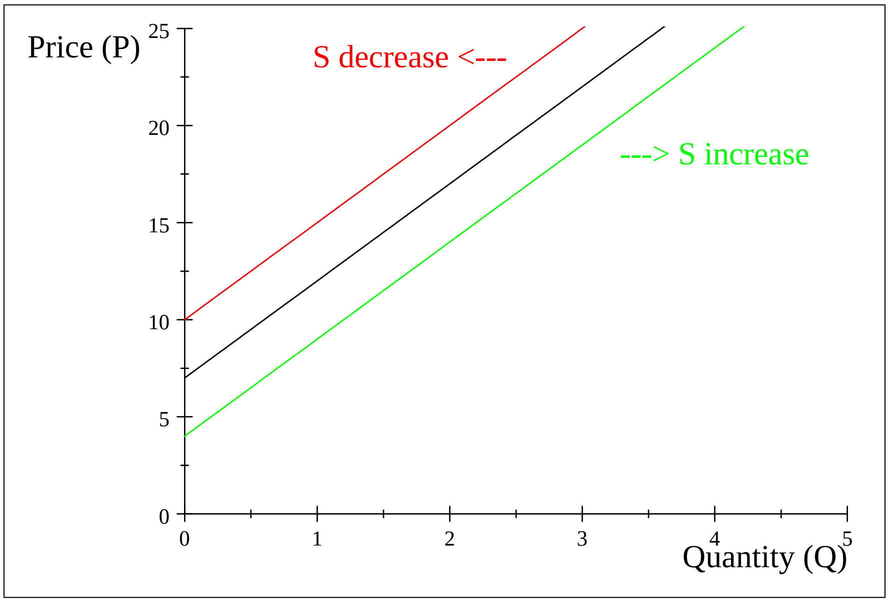


Figure 1.1: Effect of the change in price of a key resource on supply. The black line is the original inverse supply function, the red line shows a decrease in supply (increase in the price of the resource), and the green line shows an increase in supply (decrease in the price of a resource).

[1] We could solve for $Q_S$ to rewrite this function as a supply function: $Q_S = \frac{P}{5} - \frac{7}{5}$, but then we would need to put quantity on the vertical axis.

[2] For undergraduate economics students I would make a very labored point of discussing the difference between a shift in quantity supplied and a shift in supply. Simply, a shift in quantity supplied is a shift along a supply curve; a shift in supply is a shift of the entire curve.

Figure 1.1 shows the effect of an increase in the price of the resource from 2 to 3 (red line) as well as the effect of a decrease in the price of the resource from 2 to 1. The black line is the original curve. If we substitute $P_{resource} = 3$ into $P = 5Q_S + 3P_{resource} + 1$ we get $P = 5Q_S + 10$; if we substitute $P_{resource} = 1$ into $P = 5Q_S + 3P_{resource} + 1$ we get $P = 5Q_S + 4$. Note that the green line shows an increase in supply (there is more available at each price level) while the red line shows a decrease in supply (there is less available at each price level). Thinking through what happened, for the green line the price of the resource fell so we should see more supply, while with the red line the price of the resource rose so we should see less supply. While we generally think about increases and decreases as "up or down," it is best to consider increases in supply as shifts of the curve to the right and decreases in supply as shifts of the curve to the left. This rule of thumb will also work for our discussion of shifts in demand.

# 2 Demand

We begin with the Law of Demand:

> There is an inverse (negative) relationship between the price of a good and the quantity demanded.

Restating, as the price of a good increases, the quantity demanded will decrease. You might also hear some people say that demand is downward sloping. These all mean the same thing. We can show this relationship with a graph:

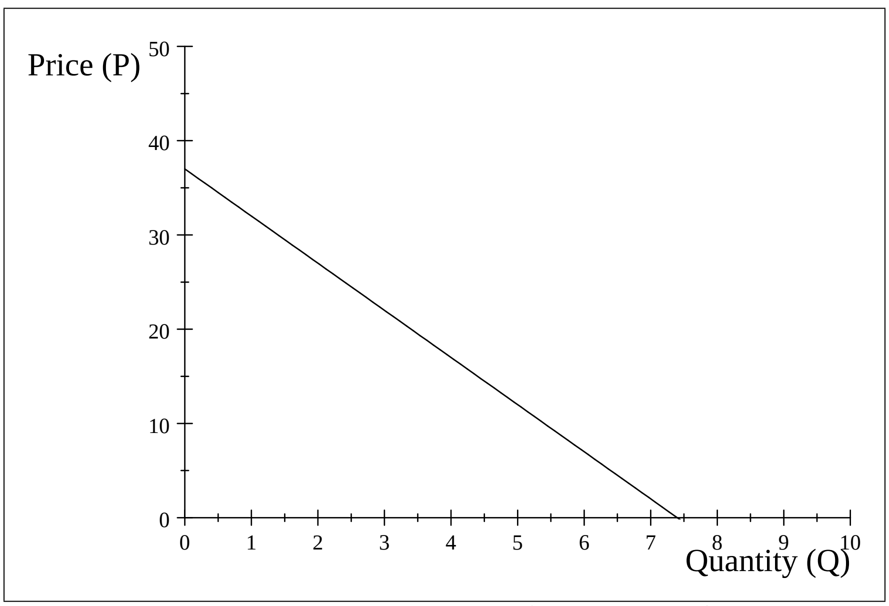


Figure 2: Inverse demand curve for $P = 37 - 5Q_D$.

For Figure 2, I have used the linear function $P = 37 - 5Q_D$, where $P$ is the price of the good and $Q_D$ is the quantity demanded. Similar to supply, we are actually graphing the inverse demand function given the conventions in the field about constructing the graph.[3] Also, we will typically work with linear functions though, like with supply, the actual functions are likely curved. Each point on the curve tells us the quantity demanded at each price.

## 2.1 Shifts in demand

As with supply, all factors except price and quantity are held constant in the graph of demand. However, there are a few factors that can cause the entire demand curve to shift. Some factors related to markets are changes in the price of a substitute good, changes in the price of a complementary good, and changes in

[3] Again, if we rewrite the equation in terms of the quantity variable, $Q_D$, we would have a demand function. So we would have: $Q_D = \frac{37}{5} - \frac{P}{5}$.

the expected future price of a good. In addition, there are factors related to consumers: changes in income, changes in the number of consumers in the market, demographic changes, and changes in preferences[4] can all shift demand curves.

As an example, use the inverse demand function from before, $P = 37 - 5Q_D$. Suppose that consumer income is represented by $Y$, and when we include consumer income in the inverse demand function we now have: $P = 17 + 4Y - 5Q_D$. As with supply, we replace the new variable in the inverse demand function with its constant value so we can graph it. Let the constant value of income be $Y = 5$. That will bring us back to our original function, $P = 37 - 5Q_D$.

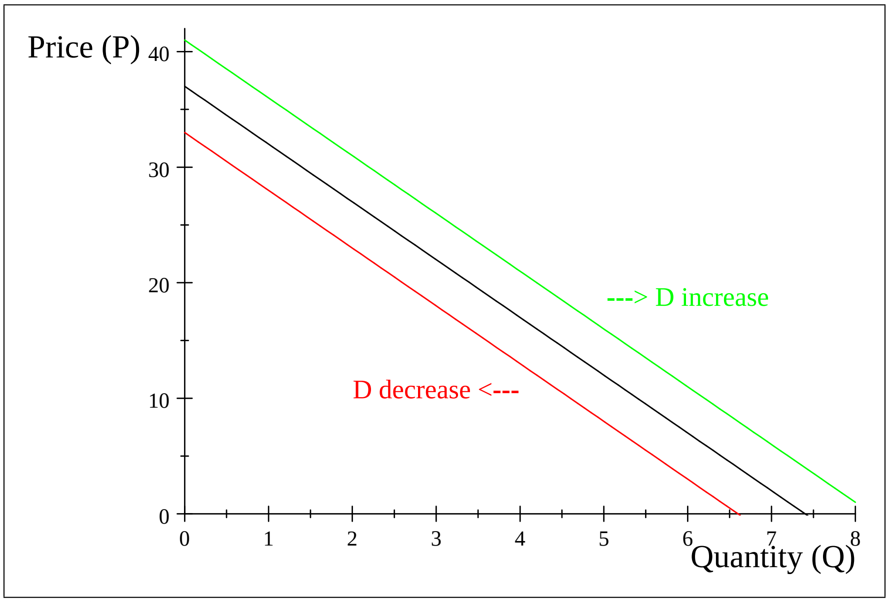


Figure 2.1: Effect of the change in income on demand.. The black line is the original inverse demand function, the red line shows a decrease in demand (decrease in income), and the green line shows an increase in demand (decrease in income).

Figure 2.1 shows the effect of a decrease in income from 5 to 4 (red line) as well as the effect of an increase in income from 5 to 6. The black line is the original curve. If we substitute $Y = 4$ into $P = 17 + 4Y - 5Q_D$ we get $P = 33 - 5Q_D$; if we substitute $Y = 6$ into $P = 17 + 4Y - 5Q_D$ we get $P = 41 - 5Q_D$. Note that the green line shows an increase in demand (there is more desired at each price level) while the red line shows a decrease in demand (there is less desired at each price level). Thinking through what happened, with more income consumers are able to purchase more at every price level, and with less income the consumers are able to purchase less at every price level. As with supply, I find it helpful to think of a decrease as a shift of the entire curve to the left, and an increase as a shift of the entire curve to the right.

# 3 Equilibrium

In the 1800s, there was a debate as to whether supply or demand was the important factor in determining price in a market. Alfred Marshall, a British economist in the late 1800-early 1900s who published the dominant economic text of the era, compared supply and demand to the blades of a pair of scissors. It was not the upper blade or lower blade that did the cutting but both working together, and supply and demand worked in the same way in determining price. To determine equilibrium price we want to put supply and demand on the same graph:

[4] We will discuss preferences shortly.

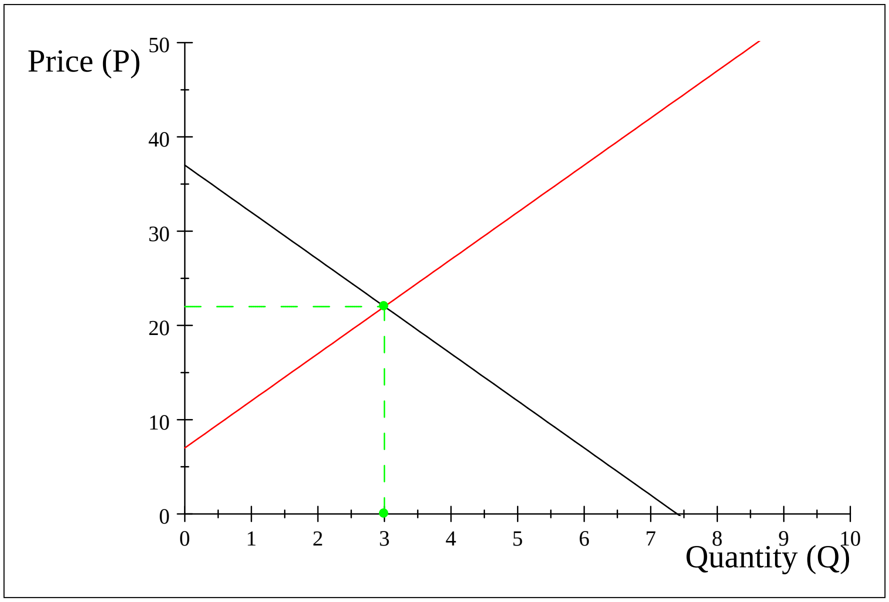

Figure 3: Determination of equilibrium price and quantity using supply and demand.

Figure 3 shows both the inverse supply, $P = 5Q_S + 7$, and inverse demand, $P = 37 - 5Q_D$, functions on the same graph. The black line is the demand curve and the red line is the supply curve. The point at which they intersect is the equilibrium price and quantity.[5] From the graph, it seems like they intersect at a quantity of 3 and a price of 22, which is where the dashed green lines are. We can confirm that mathematically by using the fact that $Q_D = Q_S$ at the equilibrium point, and then solving these two equations for $P$ and $Q$:

$$\begin{aligned} P &= 5Q + 7 \\ P &= 37 - 5Q \end{aligned}$$

Both equations are written in terms of $P$ so we can just set them equal to each other:

$$\begin{aligned} 5Q + 7 &= 37 - 5Q \\ 10Q &= 30 \\ Q &= 3 \end{aligned}$$

Substituting $Q = 3$ into the other inverse supply and inverse demand functions will give $P = 22$. The goal of this course is not to have you all do a bunch of algebra, but I do want to show some of the math so that you know how the figures and equations are related.

It is worthwhile to think a little deeper about the concept of equilibrium price and quantity, and the concept of equilibrium in general. If something is in equilibrium, it typically means that something is at rest or in balance; it is not changing. When children lose their balance on a balance beam, it is often said that they have "lost their equilibrium" meaning they have lost their balance. With economic models you want to think about what it is that is being balanced. In the case of the supply and demand model, it is the quantities that are being balanced or equilibrated, and the mechanism that does the balancing is price.

Price plays an important role in markets as it sends a signal to both consumers and producers about the value of the marginal unit in the market.[6] When the price is shifted away from the equilibrium price through a policy intervention, its link as a signal is altered. That is not to say there is no role for policy interventions, but one must be aware that altering prices in markets changes the incentives for consumers and producers (and that may well be the point of the policy intervention). In and of themselves, "high" prices or "low" prices are neither inherently good nor bad, they are merely signals about the market.

[5] You will find that most economic models are interested either in where there is an intersection point or where there is a tangency point.

[6] Economic analysis tends to be marginal analysis; we are interested in the price, cost, utility, etc. of an extra unit of the good. We will discuss this concept more shortly.

### 3.1 Changes in equilibrium

Assuming there are no direct policy restrictions on price or quantity, a change in equilibrium price and/or quantity will occur due to shifts in the supply or demand curve. Looking at the four potential shifts in supply and demand separately, we can analyze the direction of the predicted change in equilibrium price and quantity. We will use the inverse supply and demand functions we have been using, $P = 5Q_S + 7$ and $P = 37 - 5Q_D$, as well as the example functions for an increase and decrease in supply ($P = 5Q_S + 4$ and $P = 5Q_S + 10$) and demand ($P = 41 - 5Q_D$ and $P = 33 - 5Q_D$), to demonstrate the predicted changes. In Figures 3.1.1-3.1.4 the red line is the original inverse supply function and the black line is the original inverse demand function. The dashed black lines are the original equilibrium price and quantity, which was a price of 22 and a quantity of 3. The green line is the shifted curve in each respective figure, and the green dotted line is the new equilibrium price and quantity.

#### 3.1.1 Increase in supply

Figure 3.1.1 shows the effect of an increase in supply on equilibrium price and quantity. The new equilibrium price is less than the original equilibrium price and the new equilibrium quantity is greater than the old equilibrium quantity. Holding all else constant, as supply increases, equilibrium price should decrease because more of the good is available, and equilibrium quantity should increase as more of the good is available.

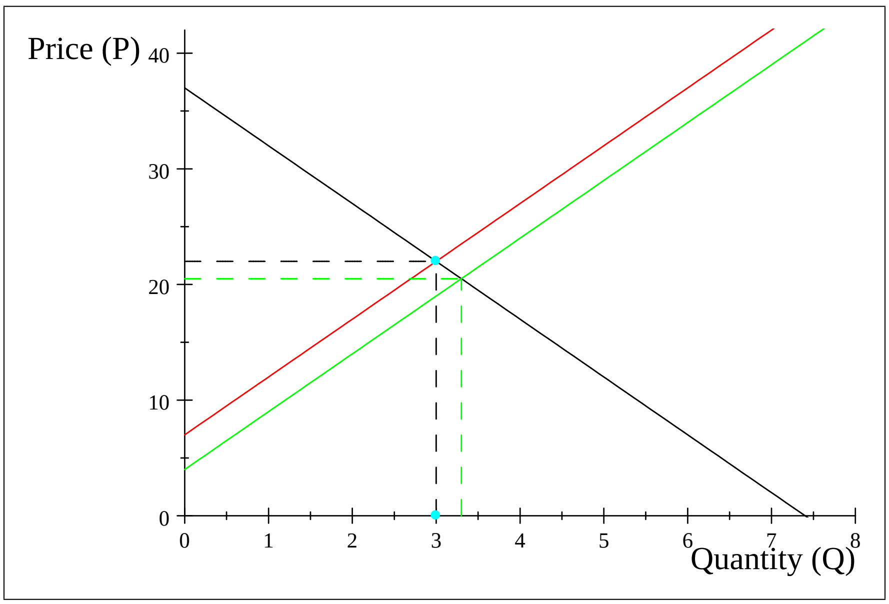


Figure 3.1.1: Effect of an increase in supply on the equilibrium price and quantity in a market.

#### 3.1.2 Decrease in supply

Figure 3.1.2 shows the effect of a decrease in supply on equilibrium price and quantity. The new equilibrium price is greater than the original equilibrium price and the new equilibrium quantity is less than the old equilibrium quantity. Holding all else constant, as supply decreases, equilibrium price should increase because less of the good is available, and equilibrium quantity should decrease as less of the good is available.

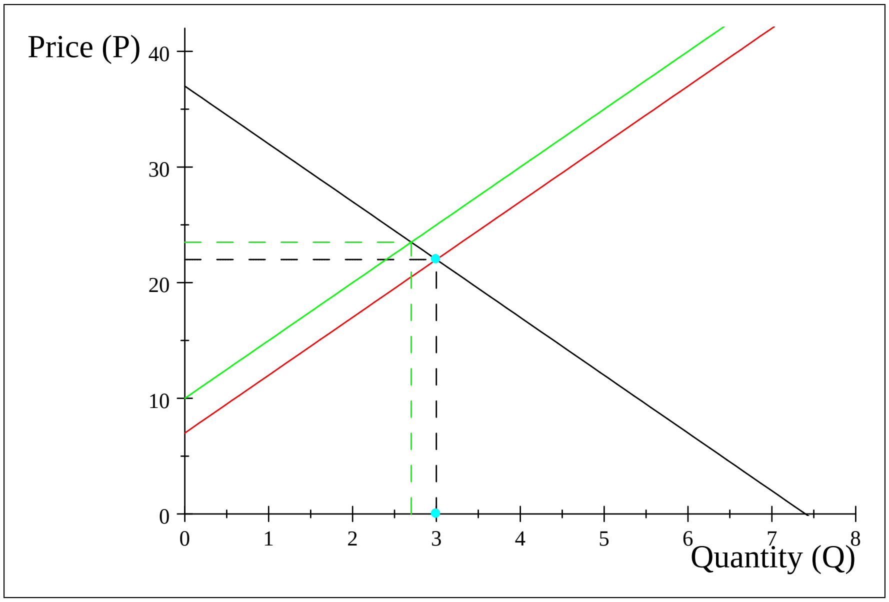


Figure 3.1.2: Effect of a decrease in supply on the equilibrium price and quantity in a market.

### 3.1.3 Increase in demand

Figure 3.1.3 shows the effect of an increase in demand on equilibrium price and quantity. The new equilibrium price is greater than the original equilibrium price and the new equilibrium quantity is greater than the old equilibrium quantity. Holding all else constant, as demand increases, equilibrium price should increase because consumers want more of the good, and equilibrium quantity should increase because consumers want more of the good.

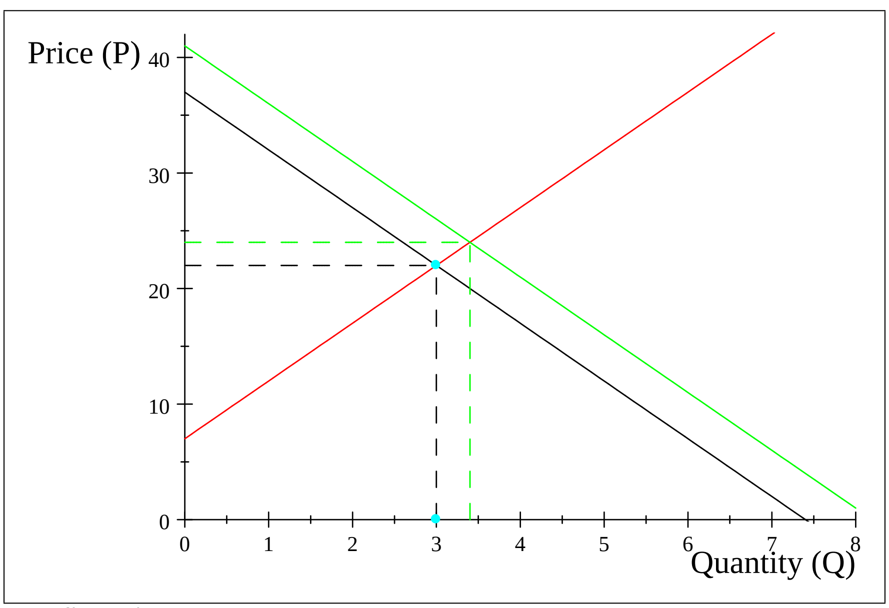


Figure 3.1.3: Effect of an increase in demand on the equilibrium price and quantity in a market.

### 3.1.4 Decrease in demand

Figure 3.1.3 shows the effect of a decrease in demand on equilibrium price and quantity. The new equilibrium price is less than the original equilibrium price and the new equilibrium quantity is less than the old equilibrium quantity. Holding all else constant, as demand decreases, equilibrium price should decrease because consumers want less of the good, and equilibrium quantity should decrease because consumers want less of the good.

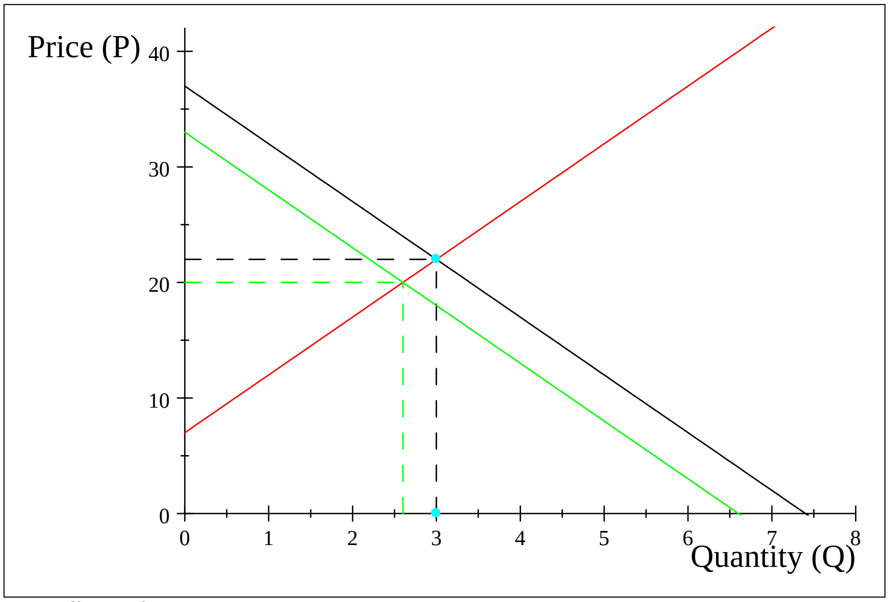


Figure 3.1.4: Effect of a decrease in demand on the equilibrium price and quantity in a market.

### 3.1.5 Shifts of both curves

When both supply and demand shift the predicted equilibrium outcome depends on both the direction of the shifts (increase or decrease) as well as the relative magnitudes of each shift. If we only know the direction of the shift we can only make a certain prediction about one of the two outcomes (price or quantity). If both curves increase, then equilibrium quantity will increase. If both curves decrease, then equilibrium quantity will decrease. If supply increases and demand decreases, then equilibrium price will decrease. If supply decreases and demand increases, then equilibrium price will increase.

# 4 Testing the model

Testing how well the supply and demand model works in a naturally occurring environment is difficult because we assume that everything except price and quantity are held constant. That assumption is very strong and unlikely to be met with naturally occurring data. Moreover, two equations (supply and demand) jointly determine the equilibrium price and quantity, so estimating an empirical model with ordinary least squares (linear regression) is unlikely to yield reliable results. As mentioned in the opening notes, if an issue arises with a benchmark model someone will try to find a way to resolve that issue. With estimating supply and demand relationships, simultaneous equation methods are such an attempt to resolve that issue. Haavelmo (1943) and Haavelmo (1944) provide an early discussion of these statistical implications. Epple and McCallum (2006) is a more recent example in which they discuss the lack of examples in econometrics textbooks for which structural estimation outperforms standard ordinary least squares..

However, using data from the naturally occurring environment is not the only way to test a model. In the 1960s economists started to use incentivized laboratory experiments to test the theoretical predictions of models. An early test of the model can be found in Smith (1962). That experiment has been replicated and extended many times over the years, in both monetized and classroom settings.[7] It shows that with a few simple rules, the supply and demand model makes accurate predictions of quantity traded and price. The July 2013 volume of the *Journal of Economic Surveys* has a collection of survey articles on market experiments.

[7] I have used a version of this experiment in undergraduate economics courses as well as in workshops with high school students. The predictions from the supply and demand model are very accurate.

### 4.1 Cautionary comments

Throughout the discussion of the supply and demand model I have mentioned that these are the equilibrium prices and quantities that will be attained if there are no policy interventions. Throughout the course we will discuss policy tools that can be used to affect price or quantity (or both) in a market. Also, these models are partial equilibrium models as the focus is only on predicting price and quantity in the specific market under study. For some markets, changes in that market may not have widespread effects in other markets. The market for toothpicks is one example – changes in that market are unlikely to have significant changes on most other markets. However, if the market we were studying was oil or gasoline, then limiting our analysis to only the effects in that market likely misstates the effect of a policy change on social welfare as oil and gasoline are key determinants of supply and demand in many other markets.

## References

[1] Epple, Dennis and Bennett T. McCallum (2006). Simultaneous Equation Econometrics: The Missing Example. *Economic Inquiry* 44:2, 374-384.

[2] Haavelmo, Trygve (1943). The Statistical Implications of a System of Simultaneous Equations. *Econometrica* 11:1, 1-12.

[3] Haavelmo, Trygve (1944). The Probability Approach in Econometrics. *Econometrica* 12:Supplement, iii-115.

[4] Smith, Vernon L. (1962). An Experimental Study of Competitive Market Behavior. *Journal of Political Economy* 70:2, 111-137.