Economists use the associated models of **supply and demand** to explain how market price and quantity exchanged are determined and to predict how prices and quantities change across time and space. **Demand** refers the plans of buyers to purchase different commodities; the quantity that (potential) buyers are willing and able to purchase is inversely related to price, given other influences (1) money income, (2) the size of the household, (3) the prices of other goods they might have bought instead, and (4) their tastes and preferences. The **law of demand** states that, other factors (1–4) remaining constant, buyers will purchase less of a commodity at a higher price than they would have purchased at a lower price. In a **competitive market** all potential buyers are *price takers,* meaning that they have the option of buying as little or as much as they want at the prevailing price, but they *individually* do not directly influence that price. Hence, since different prices might prevail at different times or places, it behooves the purchaser to have a plan of action, a list of *contingent purchases* that would occur at different prices.

A Household's Demand for Apples

Table 4-1 depicts the Adams family's (that is, Abigail Adams's) demand schedule for apples. A demand schedule is a list of the alternative quantities demanded at alternative prices.[1] For this household, apples are *priced out of (their) market* at any price of \$1 or more. We represent this algebraically as: for all $P \geq \$1$, $q_d = 0$. If the price were \$0.95, Abigail would wish to purchase 1 apple a day, perhaps dividing it among five family members by making a small quantity of applesauce. If the price were \$0.90 *instead of*[2] \$0.95, she would attempt to purchase 2 apples. The first apple would be worth \$0.95, but the household buys it for only \$0.90, receiving a nickel of **consumer surplus.** At a price of \$0, the household decides to "purchase" 20 apples, not an infinite number. That is because at some point, goods become bads—apples spoil, take up scarce shelf space, and eating too many apples causes tummy aches.

The first column shows the price, the *independent variable* since the price is determined by forces beyond the Adams family's control. The second column shows the quantity demanded—the amount that Abigail would like to buy, per day, at that price. Abigail maximizes her satisfaction[3] from the consumption of apples by purchasing apples so that they break even on the last apple purchased. That is, at \$1.00, they buy no apples since do not believe any apple is worth \$1.00. At \$0.50, they buy 10 apples, since the last apple provides as much satisfaction as would \$0.50 spent on some other commodity.[4]

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[1] Another way of depicting consumer demand is with an equation. In this case, $Q_d = 20 - 20P$ (read quantity demanded equals 20 minus one-half the price), where Q_d is the quantity of apples the household would purchase each day, and P is the price (in dollars per apple).

[2] This highlights the fact that the demand schedule refers to what the consumer would do at different prices at the same time and place, and not necessarily what would happen over time (since, over time, other factors like incomes, other prices, the size of the family or their tastes for apples might change).

[3] Throughout this text, we assume that Moms are altruistic – that is, they obtain happiness when either they or their family have "more"; the mark of altruism is the willingness to sacrifice one's own consumption to increase the consumption of another.

[4] This is how the law of diminishing marginal utility translates into a law of demand. If the satisfaction from the last unit decreases with the amount consumed, and since consumers have limited income, they will stop consuming when the last dollar spent on the commodity in question gives them just as much satisfaction as spending that dollar on some other commodity instead. Hence, once the household has allocated

Since the first nine apples provide greater satisfaction than the tenth apple does, the consumer receives a consumer surplus on *infra-marginal* units of the commodity. Hence, the column total value is computed by adding the *bid price*[5] for the first apple, plus the bid price for the second apple, and so forth. The actual expenditure is the price (of all the apples) times the quantity purchased. Hence, the consumer surplus is the difference between the total value of the commodity and the total expenditure.

Demand Schedule

Price per Apple	Quantity Demanded per Day	Total Value	Total Expenditure	Consumer Surplus
$1.00	0		$0.00	$0.00
$0.95	1	$0.95	$0.95	$0.00
$0.90	2	$1.85	$1.80	$0.05
$0.85	3	$2.70	$2.55	$0.15
$0.80	4	$3.50	$3.20	$0.30
$0.75	5	$4.25	$3.75	$0.50
$0.70	6	$4.95	$4.20	$0.75
$0.65	7	$5.60	$4.55	$1.05
$0.60	8	$6.20	$4.80	$1.40
$0.55	9	$6.75	$4.95	$1.80
$0.50	10	$7.25	$5.00	$2.25
$0.45	11	$7.70	$4.95	$2.75
$0.40	12	$8.10	$4.80	$3.30
$0.35	13	$8.45	$4.55	$3.90
$0.30	14	$8.75	$4.20	$4.55
$0.25	15	$9.00	$3.75	$5.25
$0.20	16	$9.20	$3.20	$6.00
$0.15	17	$9.35	$2.55	$6.80
$0.10	18	$9.45	$1.80	$7.65
$0.05	19	$9.50	$0.95	$8.55
$0.00	20	$9.50	$0.00	$9.50

Table 4-1

The **demand curve** is another way to depict the inverse relation between price and quantity demanded. We plot the quantity on the horizontal axis; technically, the good we are plotting on the vertical axis is the bid price. This means that, for any quantity, the area of the *trapezoid* between 0 and the number of units (consumed) is the total value, the area of the rectangle (price times quantity) is the total expenditure, so consumer surplus is the area of the triangle below the demand curve and above the prevailing price. Note that Figure 4-1 depicts a prevailing price of $0.50, and the household responds by purchasing

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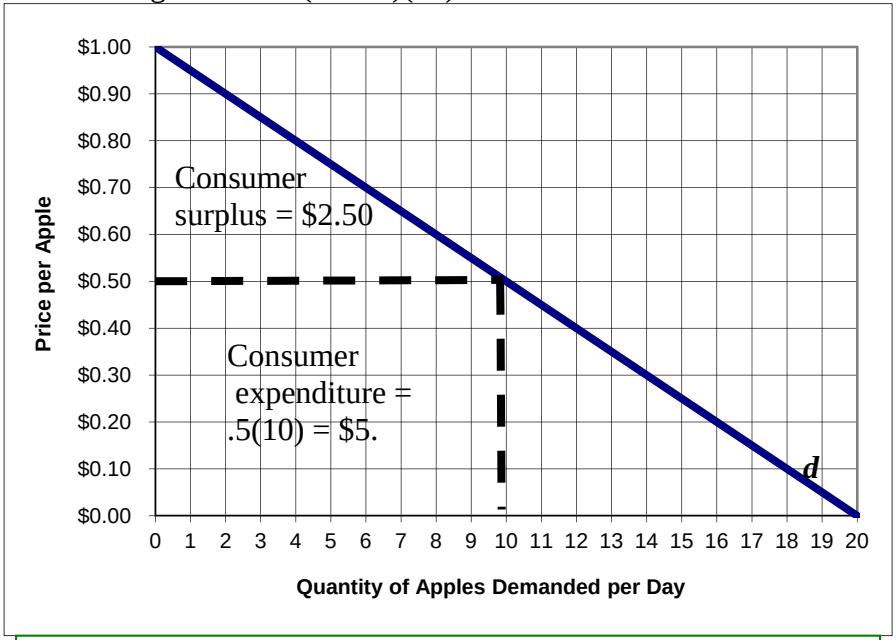
their budget, the economist can infer that for any two goods, *x* and *y* purchased, $\frac{MU_x}{p_x} = \frac{MU_y}{p_y} > \frac{MU_z}{p_z}$, where *MU* stands for *"marginal utility*," *p* stands for *price*, and *z* is some commodity the household could have purchased, but did not.

[5] While price is the independent variable, the bid price is treated as the dependent variable, since, as quantity increases, the amount bid for the next unit decreases.

10 units. The total expenditure is $5.00 ($0.50 times 10 apples). The consumer surplus is the area of the triangle: $CS = ½(10 - 5)(10) = \$25$.[6]



To read a demand curve, find the price on the vertical axis, follow a perpendicular line to the demand curve (*d*), and drop a perpendicular line to the horizontal axis. When price is $0.50, quantity demanded is 10 apples a day.

Figure 4-1

Table 4-1 and Figure 4-1 predict that the household would achieve maximum satisfaction if apples were free. However, as long as resources are scarce, apples will not be free. If the market price of apples really were zero, no apple producers would deliver apples to the market, and the household's demand for apples would go for naught. To truly understand the nature of the market, it is important to understand **supply** as well as demand.[7]

Supply Decisions by a Price-Taking Apple Producer

Consider Johnny Appleseed, whose apples are ready for harvest. Some apples are within an arm's reach, and can be harvested with little effort, costing, say $0.05 per apple. Other apples are just out of arm's reach, and cost $0.10 each to pick, and so forth. To maximize profit, Johnny should start with the least costly apples, and continue to pick apples until the cost of the last apple picked (its *marginal* cost) equals its selling price. The **marginal cost** of a commodity is the opportunity cost necessary to produce the last

[6] The difference between the arithmetical calculation of consumer surplus as $2.25 in Table 4-1, and the $2.50 geometric calculation in Figure 4-1 is that quantity is treated as a discrete variable in the table, and a continuous variable in the diagram.

[7] In the early days of "communist" Russia, Lenin proclaimed that bread should be free. The government bought all grain and distributed free bread on a first-come, first-serve basis. Ironically, farm animals ate bread (which had fewer nutrients) instead of grain, which had positive opportunity costs. It took the Soviet Union 70 years to realize that peasants knew more economics than the government bureaucrats did!

unit. We imagine that today's marginal cost of apple harvesting is given by Table 4-2.[8] The first column gives the (hypothetical) price per apple, and the second column gives the number of apples Johnny would pick for delivery to market. The third column appears identical to the first, except that the first column is labeled price (the independent variable, since Johnny is also a price taker), and the third column is marginal cost (which is dependent on the quantity produced). By harvesting that quantity for which marginal cost equals price, Johnny's total revenue equals price times quantity, given in column 4. The variable cost is the sum of the marginal cost for all the units harvested.

Price per Apple	Quantity Supplied per Day	Marginal Cost	Total Revenue	Variable Cost	Producer Surplus
$0.00	0	0	$0.00	$0.00	$0.00
$0.05	50	$0.05	$2.50	$1.25	$1.25
$0.10	100	$0.10	$10.00	$5.00	$5.00
$0.15	150	$0.15	$22.50	$11.25	$11.25
$0.20	200	$0.20	$40.00	$20.00	$20.00
$0.25	250	$0.25	$62.50	$31.25	$31.25
$0.30	300	$0.30	$90.00	$45.00	$45.00
$0.35	350	$0.35	$122.50	$61.25	$61.25
$0.40	400	$0.40	$160.00	$80.00	$80.00
$0.45	450	$0.45	$202.50	$101.25	$101.25
$0.50	**500**	**$0.50**	**$250.00**	**$125.00**	**$125.00**
$0.55	550	$0.55	$302.50	$151.25	$151.25
$0.60	600	$0.60	$360.00	$180.00	$180.00
$0.65	650	$0.65	$422.50	$211.25	$211.25
$0.70	700	$0.70	$490.00	$245.00	$245.00
$0.75	750	$0.75	$562.50	$281.25	$281.25
$0.80	800	$0.80	$640.00	$320.00	$320.00
$0.85	850	$0.85	$722.50	$361.25	$361.25
$0.90	900	$0.90	$810.00	$405.00	$405.00
$0.95	950	$0.95	$902.50	$451.25	$451.25
$1.00	1000	$1.00	$1,000.00	$500.00	$500.00

Table 4-2

Producer surplus is also called **gross profit**: revenue minus variable cost. Since all the other costs of apple production have already been incurred by the time the apples are harvested, the only way to recover those costs (e.g., leasing the land, renting the tractor, wages for planters, interest on the bank loan, property taxes) is to sell the harvested apples. Since these other costs are **fixed**, *maximizing producer surplus also maximizes economic profit.* In Figure 4-2, we imagine that the market price is $0.50 per apple. The producer delivers 500 apples to market, receiving revenue of $250 = ($0.50 x 500). Variable cost is the area underneath the supply curve [$125 = ½(500)($.50)], so producer surplus is revenue minus variable cost: Surplus = $250 – $125 = $125. In this example, the

[8] The equation for marginal cost in dollars is $MC = .001q$, where q is the number of apples harvested. The average variable cost equals ½ MC, so that variable cost equals $.0005q^2$.

apple producer would maximize profit by expanding output until marginal cost (equal to .001q) equals price, P. Substituting, we get .001$q = p$, or $q_s = 1000p$.

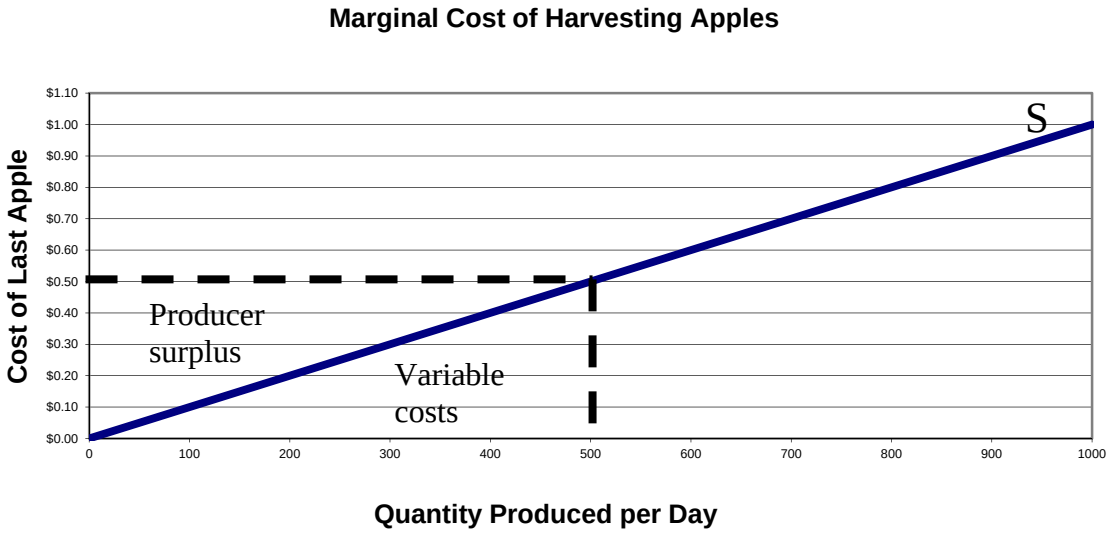


Figure 4-2

Market Supply and Market Demand

So far we have seen how a mother's attempt to manage the family budget generates her demand for apples and how an apple producer's attempt to maximize profit generates his supply of apples. Next we address how individual demand curves are aggregated into **market demand.** Suppose that the Adams family is a *statistically representative household,* meaning that its demand for households is representative for a population of, say, 100,000 households. Since an apple eaten by one person is one less apple for everyone else,[9] we obtain the market demand by adding the quantities demanded at alternative prices by all households. Given that the Adams's demand is given by $q_d = 20 - 20p$, where q_d is the number of apples demanded per day, and p is the price per apple (in dollars), market demand is:[10]

$$Q_d = \sum_{i=1}^{i=100,000} q_{d_i} = 100,000(20 - 20p) = 2,000,000 - 2,000,000p$$

The market demand curve has its price intercept at $20, where no apples are purchased, and has its quantity intercept equal to 2,000,000.

Similarly, individual supply curves are aggregated into market supply. In our example, Johnny Appleseed's apple supply equation is $q_s = 1000p$. If his is a statistically

[9] Recall that a pure private good is consumed by one person or family, while pure public goods are consumed by all people. Many goods fall between these two extremes. Two hundred people may watch the same movie, but there are limits to how many people can fit into the same theater.

[10] This forbidding equation is really quite logical. We use capital letters to represent market quantities and lower case letters to represent individual quantities. When we add the quantity demanded for each household at each price, it is equivalent to multiplying the demand equation for the statistically representative household by the number of households in the population.

representative firm in a market with, say, 2000 apple produces, the market supply equation would be given by:

$$Q_s = \sum_{j=1}^{2,000} q_{s_j} = 2000(1000\,p) = 2,000,000\,p$$

As the individual firm's supply curve is positively sloped, it follows that the market supply curve also has a positive slope.

In a competitive market, all buyers *willing and able* to purchase the commodity and all sellers *willing and able* to deliver the commodity can participate.[11] Furthermore, if the commodity is homogeneous, like apples, then all buyers and sellers will be **price takers.** Buyers will seek out apple bargains; any sellers holding out for higher prices will (eventually) sell no apples. The **market demand curve** is the sum of the quantities demanded by all (potential) buyers at each possible price. The **market supply curve** is the sum of all the quantities supplied by all (potential) producers. Because the supply and demand curves are relevant only for a specific time and place, we treat all other factors (called exogenous variables) as predetermined constants.

Table 4-3 shows the independent responses to buyers and sellers to different market prices.

Price per Apple	Quantity Supplied	Quantity Demanded	Market Situation	Price Change
$0.00	0	2,000,000	Excess demand	positive
$0.05	100,000	1,900,000	Excess demand	positive
$0.10	200,000	1,800,000	Excess demand	positive
$0.15	300,000	1,700,000	Excess demand	positive
$0.20	400,000	1,600,000	Excess demand	positive
$0.25	500,000	1,500,000	Excess demand	positive
$0.30	600,000	1,400,000	Excess demand	positive
$0.35	700,000	1,300,000	Excess demand	positive
$0.40	800,000	1,200,000	Excess demand	positive
$0.45	900,000	1,100,000	Excess demand	positive
$0.50	**1,000,000**	**1,000,000**	**Equilibrium**	**none**
$0.55	1,100,000	900,000	Excess supply	negative
$0.60	1,200,000	800,000	Excess supply	negative
$0.65	1,300,000	700,000	Excess supply	negative
$0.70	1,400,000	600,000	Excess supply	negative
$0.75	1,500,000	500,000	Excess supply	negative
$0.80	1,600,000	400,000	Excess supply	negative
$0.85	1,700,000	300,000	Excess supply	negative
$0.90	1,800,000	200,000	Excess supply	negative
$0.95	1,900,000	100,000	Excess supply	negative
$1.00	2,000,000	0	Excess supply	negative

Table 4-3

[11] See Thomas M. Carroll, David H. Ciscel, and Roger K. Chisholm, "The Market as a Commons: An Unconventional View of Property Rights," *Journal of Economic Issues*, 13 (June 1979), 605–627.

If apples were free (p = \$0), households would demand 2,000,000, but apple orchards would supply no apples – this is an extreme case of excess demand, a price at which quantity demanded exceeds quantity supplied. Disappointed would-be apple buyers will offer to pay higher prices to obtain apples. As the price rises, the quantity demanded decreases and the quantity supplied increases. Price would no longer increase when it reached \$0.50, the **equilibrium price.** The equilibrium price is that price at which the market quantity demanded (1,000,000) equals quantity supplied (also 1,000,000); when the market price equals the equilibrium price, there is no tendency for the price to change.

If we start at the other extreme, at a price of \$1.00 per apple, the quantity of apples demanded would be zero, while the quantity of apples supplied would be 2,000,000. At this price we have **excess supply**: the quantity supplied exceeds quantity demanded. In this case, the (would-be) apple sellers are disappointed. Johnny and other apple-proprietors fear spoilage, so in desperation they begin lowering their price. If the price cuts are gradual, we would again observe convergence on the **equilibrium price.** As price fell, quantity demanded would increase and quantity supplied would decrease until, at \$0.50 per apple, the quantity of apples demanded equals the quantity of apples supplied. All this works without government or other external interference, which leads most economists and other libertarians to support a policy of *laissez faire* – literally, *let it be*.[12]

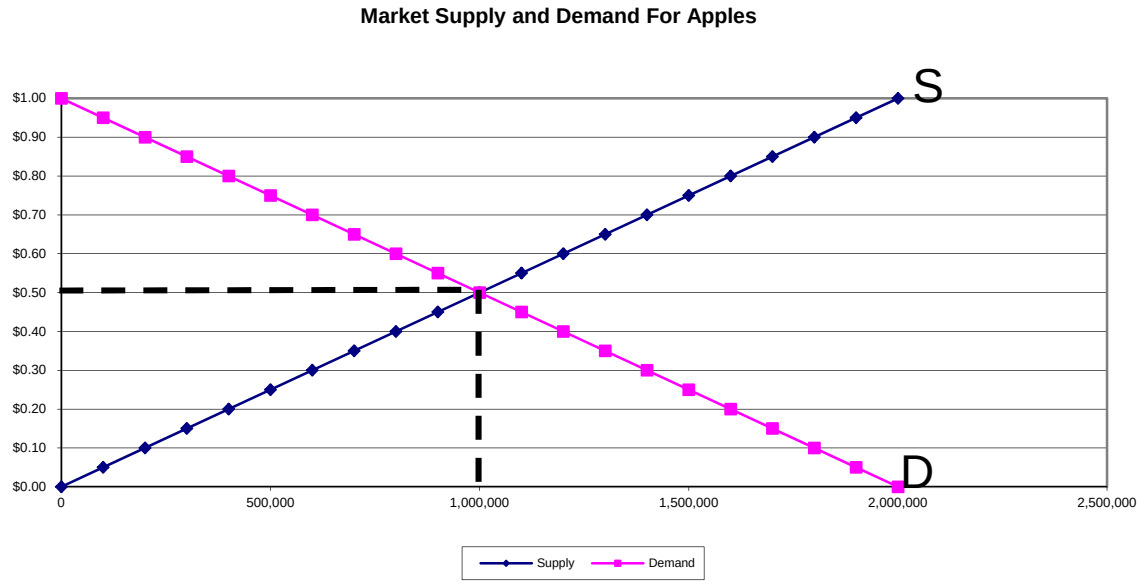


Figure 4-3

At the equilibrium price buyers can purchase all they wish to buy at that price; they have no incentive to bid the price higher. Also, at the equilibrium price, sellers are able to sell that quantity of apples that maximizes their profits; they have no incentive to reduce their price. Market equilibrium is analogous to the concept of inertia in physics:

[12] However, there would be no market for apples unless apple orchards and apples themselves were property, and promises to pay for apples and deliver apples to buyers were enforced.

an object at rest tends to remain at rest unless acted upon by an outside force. *A market in equilibrium tends to remain in equilibrium unless acted upon by an outside force*. We now turn to how markets respond to the buffeting by changes in market demand and/or market supply

Changes in Demand or Supply

When a market is in equilibrium, the plans of buyers and the plans of sellers, all contingent on the value of the market price, are reconciled. Because the demand curve is negatively sloped and the supply curve is positively sloped, the market equilibrium price is unique for any given market demand curve and a corresponding market supply curve. As long as the demand and supply curves remain where they are, the equilibrium price and equilibrium quantity retain their unique values.

In a competitive market we refer to market price and market quantity as the **endogenous variables;** *endogenous* is derived from the Greek *endo* for "inside." The forces of supply and demand cause price to adjust to that level where the quantity demanded equals the quantity supplied. Market equilibrium is stable in the sense that *a market in equilibrium tends to remain in equilibrium unless acted upon by an outside force.* Those outside forces are called **exogenous variables**, literally, those variables that are determined *outside* of the market in question (here, the apple market). Changes in exogenous forces would shift either the supply curve, the demand curve, or, possibly, both curves. In our example of the apple market, the most important variables influencing the position of the demand curve include (a) household income, (b) the prices of other types of food, (c) the number of households, and (d) household preferences. The exogenous variables influencing the position of the supply curve would include (a) the price of variable factors of production (e.g., the wages of apple pickers or the rental rate for apple-picking machines), (b) the number of apple firms, (c) weather, and (d) other costs, such as the cost of transportation.

In Figure 4-4 we depict a market in equilibrium with the price of apples at $0.50 each, and the quantity of apples exchanged equal to 1 million per day. Now, suppose that an article in a leading medical journal reports that a controlled experiment at a prestigious medical school confirmed the old saw,[13] "An apple a day keeps the doctor away." The good news is that apples are effective alternatives to visits to the doctor's office. The bad news is that the increased demand will create a (temporary) excess demand for apples. The (exogenous) information shifts the demand curve to the right; at each price, the quantity of apples demanded increases. We call this change an **increase in demand** because the *position* of the demand curve shifted to the right.[14]

When the demand curve shifts from $\boldsymbol{D_0}$ to $\boldsymbol{D_1}$, the former equilibrium price, p_0 = $0.50, now generates excess demand. Quantity demanded increased from 1 million to 3 million, while quantity supplied remains at 1 million *at the prevailing price of* $0.50. Buyers, are no longer able to buy all the apples they wanted for $0.50 each. Apple growers find that they have thrice as many orders for apples as they care to fill at $0.50. In

[13] Would this constitute one of the famous "apple saws"?

[14] We can also think of demand increasing because consumers offer a higher price for each quantity consumed. However, thinking of an increase as an *upward shift* causes problems when we discuss supply shifts.

order to ration the available quantity, Johnny Appleseed and the other orchard owners raise the price of apples. As the price of apples increases, two reactions occur. The quantity of apples supplied rises along the stationary supply curve, S_0. The quantity of apples demanded decreases along the new demand curve, D_1. When the price reaches $1.00 per apple, the quantity of apples demanded and the quantity of apples supplied both stabilize at 2,000,000, and the market returns to equilibrium, although at a higher price. An increase in demand, supply constant, turns an equilibrium market into a **seller's market**, meaning that price will rise, enriching sellers, until the new equilibrium is established at a higher price and a higher quantity. *A market in disequilibrium only remains in disequilibrium until the price reaches the intersection of the prevailing demand curve and the prevailing supply curve, where quantity demanded once again equals quantity supplied.*

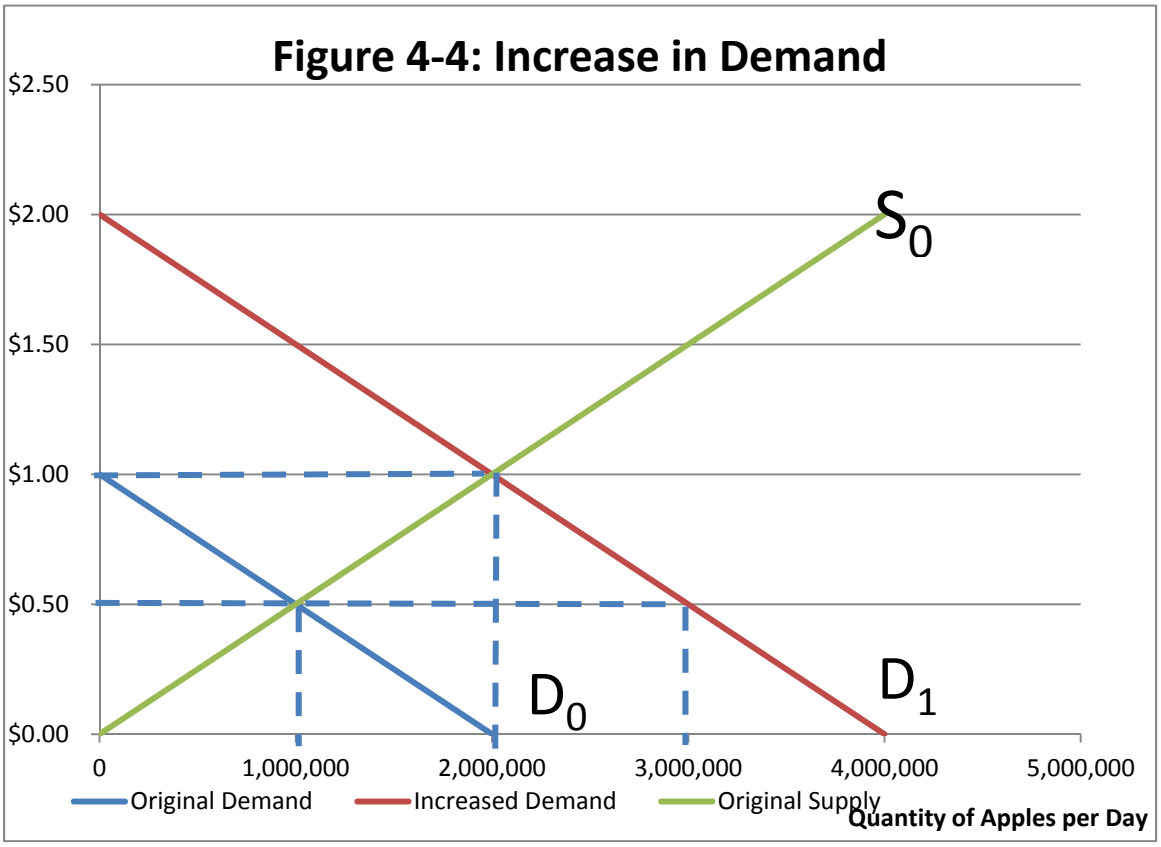


Figure 4-4

A Short Exercise

Economists place great stock in *learning by doing*. Here we will test your understanding of supply and demand analysis by having you draw your own diagram. In the space on page 62, draw a horizontal axis and label it "quantity" and a vertical axis and label it "price." Next, draw a negatively sloped line (i.e., from a high price on your vertical axis, corresponding to the good being priced out of the market to a point on the vertical axis corresponding to the amount people would want if the good were free); label the curve D_0 (for original demand curve). Next, draw a positively sloped line from a low price on the price axis; label this curve S_0 (for original supply). Locate the point of inter-

section and label the corresponding price and quantity P_0 and Q_0, respectively. Finally, connect the point of intersection and the equilibrium price and quantity with dotted lines. This is the *starting point* for any supply and demand analysis. Now we imagine that an increase in the number of produces rotates the supply curve from S_0 to the right;[15] label the new demand curve S_1. Note that the original price p_0 is no longer the equilibrium price. Identify the **excess supply**, then find the new equilibrium price and quantity (hint: they will be on the demand curve, which did not shift). These two examples show that when one curve shifts (moves to the right for an increased demand or supply, or moves to the left for a decreased demand or supply), the equilibrium price will occur along the curve *that did not shift*. Hence, a change in demand causes price and quantity to change in the same direction: an increase in demand increases equilibrium price and equilibrium quantity, while a decrease in demand decreases both equilibrium price and equilibrium quantity. By contrast, a change in supply changes the equilibrium price and quantity along the supply curve (because it does not shift). An increase in supply (the supply curve shifts to the right), causes equilibrium quantity to increase, but equilibrium price decreases. A decrease in supply (the supply curve shifts to the left) decreases equilibrium quantity but increases equilibrium price.

[15] The intercept of the supply curve is the shut-down price – where price equals minimum average variable cost. If more firms enter the market, they will still produce nothing if price is below the shutdown price, but they will produce more output at each price above the shutdown level.

Shifts in Curves versus Movement along Curves

The events in Figure 4-4 depict an important distinction between a change in demand and a change in quantity demanded. At any time and place, the market price will tend to equal the equilibrium price, since neither buyers nor sellers have any incentive to change that price. However, a change in an exogenous variable will shift the effected curve causing what was once the equilibrium price to become a temporary disequilibrium price. If that disequilibrium is **excess demand**, the price will rise as anxious buyers offer to pay higher prices; if that disequilibrium is **excess supply**, the price will fall as desperate sellers compete to sell their merchandise by lowering price. **A change in demand (the shift in the entire curve) occurs *before* the change in price.** Once the price changes, both buyers and sellers will react to the change in price by changing the quantities demanded or supplied, respectively. A decrease in price (due to a decrease in demand or an increase in supply) would increase quantity demanded and decrease quantity supplied until the new equilibrium was reached. An increase in price (due to an increase in demand or a decrease in supply) would cause quantity demanded to decrease and quantity supplied to increase, until the new equilibrium were reached.

Distinguishing between Supply and Demand Changes: The Identification Problem

To many students, the distinction between a change in demand and a change in quantity demanded seems like hair-splitting. Perhaps, if you put yourselves into the shoes of the professional economist, the distinction ought to become clearer. Imagine that you are an economist investigating the market for apples and you decide to collect information on that market on July 10, 2012, in Las Vegas, Nevada. You record the price, $0.50, and the quantity exchanged 1 million. The next day, you record the price, $0.50, and the quantity exchanged 1 million. Until either the supply or the demand curve shifts, you would be unable to identify either the demand curve or the supply curve for apples: A market in equilibrium tends to remain in equilibrium until acted upon by an outside force.

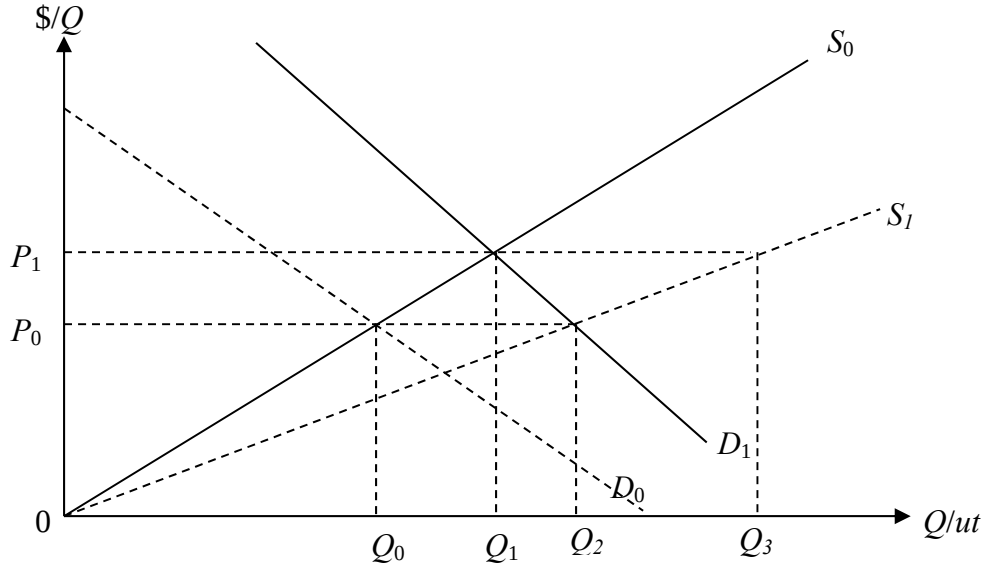


Figure 4-5

Now, suppose on the tenth day of data collection, the price increased to \$1.00 (p_1) and the quantity exchanged increased to 2,000,000 (Q_1). What happened? Perhaps you read the article on apple consumption and health and correctly identified this as a cause of an increase in apple demand. Even if you didn't see the article, however, it is pretty obvious from the pattern of price and quantity changes that a **change in demand** upset the market equilibrium. That's because while the price of applies increased by \$0.50 per apple, people consumed more apples. This violates the law of demand. It must be the case that an increase in demand (a rightward shift in the demand curve) caused a temporary excess demand, which was resolved by a price increase. The new equilibrium price and quantity are on the original supply curve, and two points are enough to identify that curve as S_0.[16]

Suppose that you spend another week or so collecting data on the apple market and consistently register a price of \$1.00 per apple and daily apple sales of 2,000,000. Suddenly, the price of apples drops back to \$0.50 and you record apple sales at 3 million. Now we record a violation of the law of supply – in theory, when price falls, sellers produce less. However, when supply increases, quantity supplied increases due to some factor other than price – in this case, more profitable apples attracted additional apple sellers into the market. The quantity supplied increased to Q_3, although this quantity went unobserved in sellers' inventories. The excess supply reduces price to \$0.50, where the new equilibrium quantity of Q_2. Now we can connect the dots and identify the second demand curve, D_1.

When Demand and Supply Both Shift: Predictability vs. Ambiguity

When only one of the two curves – market supply or market demand – shifts, the new equilibrium price and quantity will change unambiguously along the curve that did not shift. Often, however, either by coincidence or by a series of predictable events, a market might experience simultaneous shifts in both the demand and the supply curve. In the last section we observed an increase in demand that temporarily increased price and also increased equilibrium quantity. The increase in price was temporary because the increase in supply was a predictable response of profit-maximizing sellers to an increase in apple profits. The increase in supply further increased the increase in equilibrium quantity, but reversed the change in equilibrium price. Lest you panic at the prospect of sorting out the net effect of multiple events, I present Table 4-4 to help you. The first column shows the four possible ways the two curves – supply and demand – could shift independently of each other. The second column shows the effect of that change in market conditions on the equilibrium price. For instance, an increase in demand increases the equilibrium price. The third column shows the corresponding change in equilibrium quantity: an increase in demand also increases equilibrium quantity. Table 4-4 clearly shows the effect on the market equilibrium price and equilibrium quantity when one curve shifts and the other remains stationary. When both curves shift, we simply treat each event separately and determine whether the combined effect of those shifts is clear or ambiguous. For instance, an increase in demand and an increase in supply both cause the equilibrium quantity to increase; hence, when both demand and supply increase, equi-

[16] Recall from geometry that two points are sufficient to *identify* a straight line. However, since it is possible that the supply curve might be curved instead of straight, an *econometrician* would require additional information to determine the likely *shape* of the line.

librium quantity unambiguously increases. However, the effect on equilibrium price is ambiguous. The increase in demand increases equilibrium price, while the increase in supply decreases equilibrium price. Hence, the net effect on the change in price is unclear: the price could increase, decrease, or remain the same.

Market Event	Change in Equilibrium Price	Change in Equilibrium Quantity
Increase in demand	Increase	Increase
Decrease in demand	Decrease	Decrease
Increase in supply	Decrease	Increase
Decrease in supply	Increase	Decrease

Table 4-4: Effects of Changes in Demand or Supply on Market Equilibrium Price and Quantity

What if both demand and supply curves shift? In this case, we analyze the effect of each curves shift independently, and then combine the effects of both curves. If price changes in the same direction due to the combined shifts, the change in price will be unambiguous; if the shift in one curve causes price to increase, and the other causes price to decrease, then the change in price will be ambiguous. In Table 4-5, an increase in demand and an increase in supply change price in different directions; the change in equilibrium price is ambiguous. If both demand and supply increase, both the increase in demand and the increase cause the quantity to increase; the change in quantity is unambiguous – it increases. If demand decreases and supply increases, again the change in equilibrium price is ambiguous, while equilibrium quantity decreases. An increase in demand and a decrease in supply both cause equilibrium price to increase, while the increase in demand increases quantity and the decrease in supply decreases quantity; the change in quantity is ambiguous. A decrease in demand and an increase in supply reduces equilibrium price, but also has an ambiguous effect on quantity. In short, when demand and supply change in the same direction, equilibrium quantity changes in that direction, while the change in price is ambiguous. When demand and supply change in opposite directions, the change in price changes in the direction that demand does, while the change in supply is ambiguous.

Demand	Price	Quantity	Supply	Price	Quantity	Net change in	
change	change	change	change	change	change	Price	Quantity
Increase	increase	increase	Increase	decrease	increase	ambiguous	increase
increase	increase	increase	decrease	increase	decrease	increase	ambiguous
decrease	decrease	decrease	Increase	decrease	increase	decrease	ambiguous
decrease	decrease	decrease	decrease	increase	decrease	ambiguous	decrease

Table 4-5: Effect of Simultaneous Change in Demand and Supply on Equilibrium Price and Quantity

Before we leave this discussion, I wish to remind you of the discussion of the *efficient* way to learn economics from chapter 2. For many of your courses the obvious strategy seems to involve memorizing definitions and concepts. Alas, this tendency is often reinforced by professors who design exams that reward regurgitation. Further, if

those exams do not revisit previously tested concepts, then students succeed by cramming information into short term memory, and then discard it. Anticipate their dismay when they discover – often too late – that employers or clients expected them to remember and understand important concepts. Because economic theory has so many relevant applications, we soon encounter too much detail to digest successfully, let along remember. However, if we take the time to master the few underlying concepts, the details will take care of themselves. Even if you forget the contents of Table 4-4 and Table 4-5, you can always refresh your memory with your understanding – simply sketch the changes in demand and/or supply and viola! – instant recall.

Economics and Financial Markets: If We're So Smart, Why Aren't We Rich?

During the run up in the financial meltdown of 2008, many economists lost money, just like everybody else.[17] In retrospect, the real-estate and financial-market bubble was caused by speculative pressures that drove the prices of financial assets above their sustainable levels. Indeed, many of those assets turned out to be so worthless they have been dubbed "toxic." Many economists knew the stratospheric real-estate prices would not last forever, but knowing precisely when to sell that house or cash in one's stock is a matter of guesswork. And the reason why financial markets keep even economists (and financial analysts) guessing is partly because neither the supply nor the demand curve for financial assets can be identified using market data.

Returning for a moment to our discussion of the apple market, it is possible to identify some variables, such as weather, that would cause the supply curve to shift without changing the demand curve for apples. Similarly, it is possible to predict variables that would cause the demand for apples to change—say, a change in the price of oranges—that would not change the supply of apples.[18] However, in financial markets, the buyers and sellers turn out to be the same people—households and institutions with wealth portfolios. It follows that any change that would influence willingness to buy a share of stock (demand) would also affect the willingness to sell a share of that stock (supply). Hence, financial markets take a random walk; they are inherently unpredictable.[19]

Should this lack of ability to predict stock price fluctuations be a cause for alarm? Perhaps it should. Because the science of economics (and related disciplines like finance) cannot predict the path of stock prices, many unscrupulous (or just plain ignorant) "experts" write and sell all types of advice on how to beat the stock market. But the next time you are tempted to buy a book from a financial expert who promises to unlock the secrets of the stock market for $29.95, remember the concept of opportunity cost. If this expert is so good at predicting financial markets, why did they take time away from playing the market to write the book in the first place?

Some Applications of Supply and Demand

While economists are nearly unanimous in their trust of market competition to allocate scarce resources *efficiently*, there are many social critics who advocate govern-

[17] In 2009, the average economist received only 52% of the non-labor income (s)he had received in 2008.
[18] That is because apples and oranges require very different climates to thrive.
[19] Economists have a test for whether a time-series, such as the price of a financial asset, follows a random walk by whether it fits an equation of the form $y_t = y_{t-1} + \varepsilon_t$ where ε_t is an unpredictable stochastic term.

ment policies to remedy *unfair* market outcomes. Politicians are often willing to promise the impossible to win election, hoping that the voters will forget the promise by the time of the next election. Alas, although intelligence and integrity are both scarce commodities, neither crooks nor fools are.[20]

One form of political chicanery is **rent control**. Since there are more tenants than there are landlords, and because landlords often reside (and vote) outside of the city where they supply apartments, politicians may seek to curry favor with big-city tenants by freezing rents at what are considered "fair" levels. In Figure 4-6, we imagine that the market for rental housing is initially in competitive equilibrium at rent level R_0, with the equilibrium quantity of housing equal to Q_0. Suppose that an increase in population, or an increase in income, results in a rightward shift of the demand curve. The temporary result is an excess demand for housing: The quantity of housing demanded increases to Q', while the quantity of housing supplied (at price p_0) remains at Q_0. The natural effect of the housing shortage would be an increase in average rents from R_0 to R_1, and an increase in the quantity of housing supplied from Q_0 to Q_1. In the short run, the increase in rents might be quite steep, since it is hard to increase the supply of housing without constructing new buildings (supply is inelastic) and there are few substitutes for rental housing (demand is inelastic).[21]

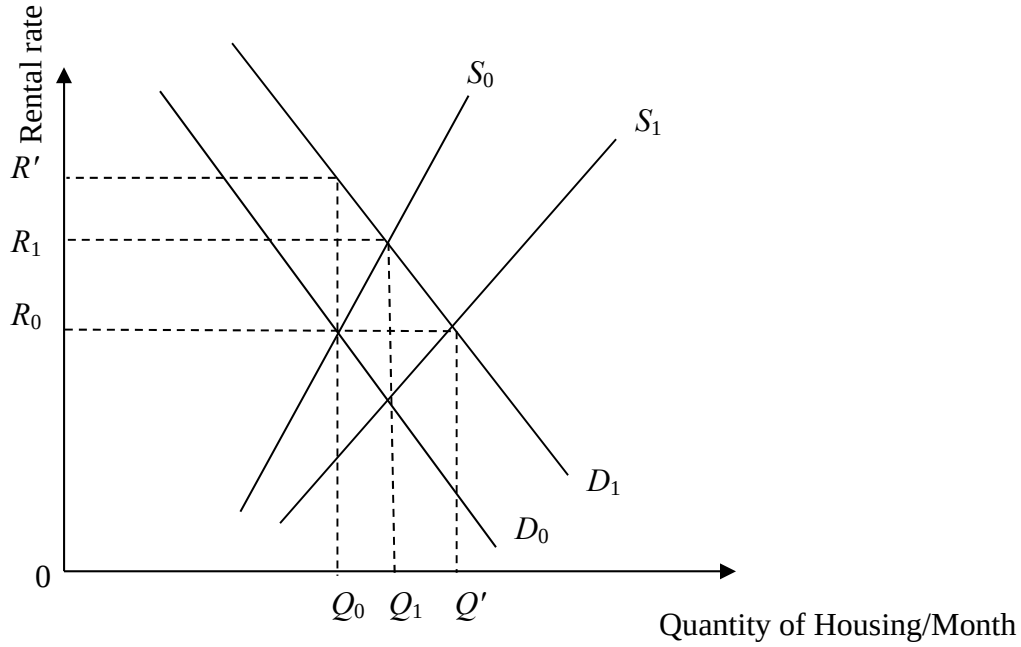


Figure 4-6

If, at rent R_1, landlords are making greater than normal profits,[22] existing and newly established apartment-rental companies will increase the number of units under

[20] My father was a life-long Democratic committeeman in Dayton, Ohio. I'll never forget his distinction between the two parties. "Tommy," he said, "you rent Democrats and buy Republicans. And we journalists just don't earn enough money to buy politicians."

[21] The supply of housing could be increased by subdividing large apartments, and refurbishing apartments that would have been retired had rents not increased. Tenants could cope with higher rents by moving back to their parents' house.

[22] We will return to this issue in Chapter 5.

construction, ultimately increasing the supply of rental housing to supply curve S_1, resulting in an increase in the number of rental units to Q', and a return of equilibrium rents to R_0. However, if rents are **frozen** at R_0, there is a permanent excess demand of $Q'–Q_0$; another name for the excess demand for housing is **homelessness**. It is no accident that the cities with the highest homeless rates—New York, Washington, Boston, Los Angeles, and Santa Monica also have rent controls.

Usury Laws

The term *usury* has a long and noble history, going back at least to the thirteenth-century church scholar, Thomas Aquinas, who proclaimed that a virtuous person would lend money and not charge interest. It has long been a problem for the Roman Catholic Church[23] that the absence of virtue is treated as a sin. Hence, Christians, all of whom were Catholics at the time, risked eternal damnation if they loaned money at interest. Since the Koran has also been interpreted as prohibiting the charging of interest, devout Muslims were also reluctant to lend money. In *Hamlet,* Polonius poetically recites Christian dogma as practical advice:[24]

Neither a borrower nor a lender be;
For loan oft loses both itself and friend,
And borrowing dulls the edge of husbandry
[Act 1, Scene 3]

Unfortunately for both Aquinas and Polonius, market economies require borrowing by businesses and lending by households if businesses are to grow. While the Protestant Reformation later modified that bit of theological foolishness,[25] there is still a tendency for governments to regulate maximum interest rates in the name of helping the poor. Las Vegas, like most cities, has a plethora of payday-loan outlets, where desperate people borrowed money at interest rates of up to 520%.[26] It is sad that people are so desperate that borrowing money at 520% seems like a good deal. The last time I checked, I counted 60 companies offering check-cashing services in the Las Vegas area. With this many firms, market competition would have reduced the equilibrium interest rate to the lowest sustainable level. Apparently, the 10% per week is the cost of doing business; for every 12 people borrowing $100 each, 11 borrowers repay their loan ($1210 in revenue) and 1 defaults (a $100 cost). That is a net gain of $10, which hardly seems excessive.[27]

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[23] I learned this from 13 years of Catholic school, which included nine years of elementary school (I was held back in the third grade because of difficulty reading), and four years at an all-boys' high school.

[24] The darker side of the Christian and Muslim prohibition against lending at interest meant that Jews, who suffered no such religious prohibition against money lending, developed a comparative advantage in banking. Alas, it is often easier to cancel a loan with a pogrom than it is to change one's theology. Aquinas's dictum against lending money at interest is, at least in part, partly responsible to the scourge of anti-Semitism to this day.

[25] That is, Martin Luther and the other protestors to papal authority found no scriptural prohibition against the charging of interest.

[26] A borrower writes a check for $110 and receives $100. The lender then cashes the check the next payday, unless the borrower pays another $10 to renew the loan. A loan of 10% per week amounts to 520% per year. This is simple interest because the borrower makes regular interest payments. If the interest of 10% per week were compounded, the annual percentage rate would be $(1.1)^{52} – 1 = 14{,}104\%$.

[27] A $10 return to $1200 at risk for a week is 0.83% per week or 53% per year. Out of this revenue, the proprietor must pay rent, salaries, and debt collection services.

Placing a **price ceiling** on the interest rate that lenders can charge has the counterproductive effect of drying up legal sources of high-interest loans, driving poor-risk borrowers to true loan sharks, who break knees in the event of loan defaults. It is difficult to understand how people with no other sources of loans are made better off by taking options away. Maybe the churches, who often lead the call for anti-usury laws, should provide low-interest loans to the poor. Of course, they should also be prepared to replenish loan funds with subsidies from Sunday collections when those once grateful borrowers are never seen in church again.

Minimum Wage Laws

Rent controls and usury laws both represent **price ceilings**, whereby governments attempt to prohibit mutually beneficial terms of trade whose prices exceed what is thought to be fair.[28] A price floor is a price control that prohibits prices below a specified level. For instance, it is a violation of federal law for an employee and an employer to agree on a wage rate below $7.25 per hour. In Figure 4-7, we confront a demand for labor curve and a supply of labor curve for unskilled workers (e.g., inexperienced high school dropouts). In this case, the supply and demand curves intersect at W_e. The minimum wage law states that any worker can sue if he or she is paid less than W_{min}.[29] If employers are forced to pay the legal minimum, the quantity of labor demanded decreases from the market-clearing level of L_e to L_1. At the same time, students who would have remained in school at wage rates of W_e mistakenly drop out of school in anticipation of earning W_{min}. The result is that minimum wage rates cause two types of unemployment. Some workers, shown by $L_e - L_1$, lose their jobs because their skills do not command a wage rate of W_{min}. Other workers, shown by $L' - L_1$, are unemployed *school dropouts*, who enter the labor force but cannot find jobs at wage rate W_{min} and are prohibited from working for W_e.

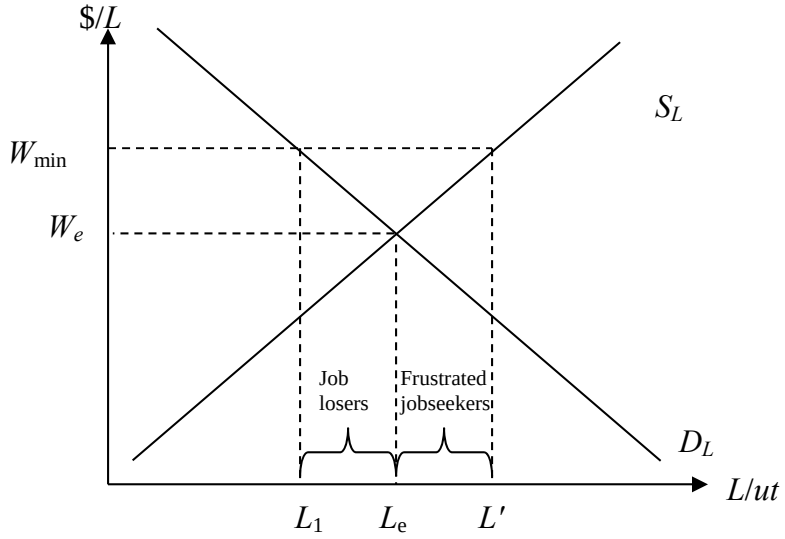

Figure 4-7

[28] In reality, rent controls favor longtime tenants over landlords and new residents, who are mostly young. Old tenants benefit from rent controls by subleasing their apartments for rents that are higher than they would be in the absence of rent controls. And, as is so often the case, no one is quite so tenacious at defending the status quo than those who receive privileges they neither earned nor deserve.

[29] The enforcement of minimum wage rates through *civil action* means that minimum wage laws are not enforced for undocumented workers.

Employment Discrimination

In a competitive market, we expect employers to discriminate in favor of the most productive workers and we expect households to discriminate in favor of the jobs that provide the most satisfaction. In Figure 4-8 the supply curve S_0 depicts the market supply curve in which all qualified workers are free to offer their labor services for the going wage, and D_0 would be the demand curve if employers hired all qualified workers. However, assume that employers in market *A* refuse to hire women for, say, construction jobs. Hence, they hire only along supply curve S_m raising the wage rate for male construction workers from W_0 (the wage rate from competitive markets) to W_A. Because they cannot obtain construction jobs, female would-be construction workers are crowded into the market for clerical workers. Although firms in market *B* hire all qualified job applicants, regardless of gender, the increase in the supply of female workers shifts the supply curve in market *B* from S_0 to S_1, reducing the wage rate in market *B* to W_B.

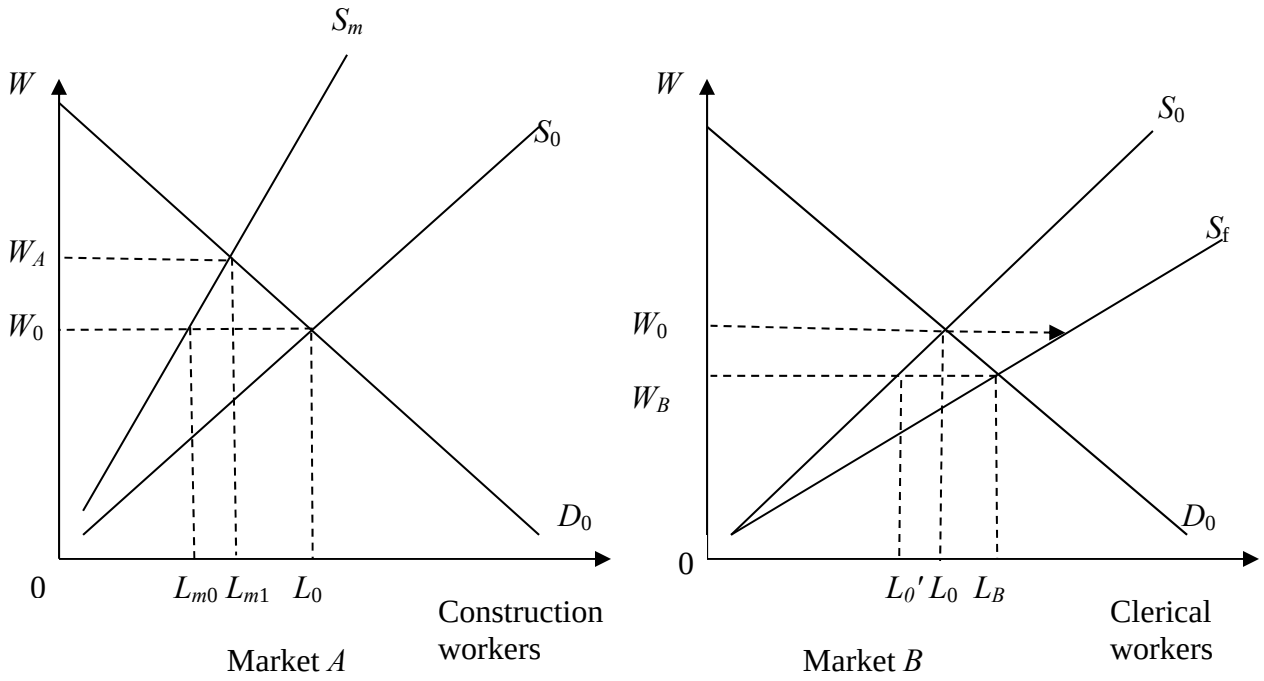

Figure 4-8

If labor markets were truly competitive, L_{m0} workers in the construction industry would be male and the remainder ($L_0 - L_{m0}$) would be female. Excluding females from the market would create an excess demand of $L_0 - L_{m0}$ at wage rate W_0; the excess demand would cause employers to bid up the wage rate to W_A, which attracts an additional $L_{m1} - L_{m0}$ male workers into the market. In the market for clerical workers, the displacement of $L_0 - L_{m0}$ women into the market *B* would shift the supply curve to S_1, which will reduce the wage rate to W_B. Some of the workers originally employed at W_0 drop out of market B, most likely male former clerical workers who enter the market for construction workers.

The consequence of employment discrimination on the relative income of the preferred group (men) and the victims of discrimination (female) is independent of what *motivates* discrimination. For instance, employers in market *A* may be prejudiced—they be-

lieve that women make poor construction workers, and so they refuse to hire them; likely they would complain that they have nothing against women, in fact, most of the men in market *A* are married to women. But, if women are not hired as construction workers, the employer prejudice will be a self-fulfilling prophecy. Alternatively, the construction union may exclude women from apprenticeship programs, possibly due to prejudice, but also because unions wish to maximize the dues they can collect from male construction workers. The point is that discrimination in one market (*A*) reduces the wage rate in market *B*, even if no employers in market *B* discriminate against women.

Medical Care

With a feeling of *déjà vu*, health care costs are once more a major campaign issue in the 2008 presidential election, leading the Obama Administration to pass the Affordable Care Act of 2009. Then, as in 1993 when the Clinton Administration previously tackled the issue, the consensus is that the price of health care is too high and the quantity of health care provided is too low. One major problem is that most people do not pay the direct cost of their health care, relying on insurance companies, or the government, to pay that cost. Another little-noted problem is that medical care and medical care commodities – particularly pharmaceuticals – are sold in monopoly markets. Fewer residents of the USA attend medical school than in other developed countries – and even many less developed countries. As we will see in chapter five, monopolies raise price by *reducing* output. Each physician commands a higher salary if there a fewer physicians offering services. Drug companies can charge $1 each for pills that cost a penny to manufacture because they have patents.

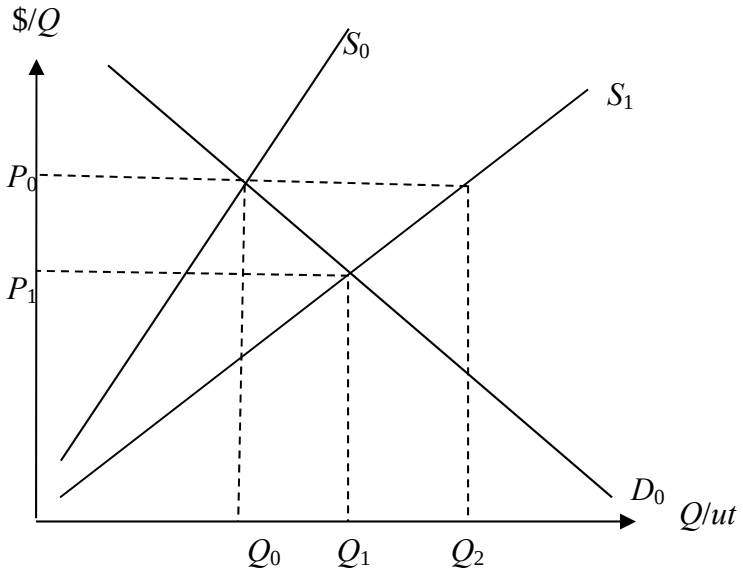

Figure 4-9

We have seen that the market price and quantity of health care will be established where the demand curve intersects the supply curve, shown at P_0 and Q_0, respectively in Figure 4-9. As long as the supply curve remains at S_0 and the demand curve remains at D_0, the market price will remain at P_0. Any attempt to increase the number of people covered by insurance will merely increase the demand for health care, raising the price above P_0. If the government were serious about making health care more affordable, it

would introduce policies to shift the market *supply* curve to the right. For instance, suppose the government encouraged medical schools to double the number of medical students. Eventually the supply curve of medical services would shift, say from S_0 to S_1. If the price of medical care (largely dependent on physician's fees) remained at P_0, there would be an excess supply of $Q_2 - Q_0$ hours of available medical services. Competition among physicians would reduce their pay, eventually reducing the price of health care to P_1. At this price, some physicians would leave medicine for other occupations (becoming medical school professors, taxidermists, or funeral directors), while the quantity of health care demanded would rise to Q_1. Gradually health care professionals could be referred to as *ambulance chasers* because they are so desperate for work that they actually show up at automobile accidents and offer their services to the injured. What a concept!

By Way of Review

Supply and demand are crucial components of a market economy and understanding them is vital to understanding and passing an economics course. **Demand** refers to the contingent plans of buyers, reflecting their willingness to buy more of a commodity at a lower price than they would have been willing to buy at a higher price. **Supply** refers to the tendency of sellers to offer more for sale at higher prices than they would be willing to sell at lower prices. The price and quantity where the supply and demand curves intersect identifies the **market equilibrium**. A price higher than the equilibrium price causes **excess demand**; excess demand causes the price to rise until the equilibrium price is reached. A price lower than the equilibrium price causes **excess supply**; excess supply causes the price to fall until the equilibrium is achieved.

In order for competitive markets to allocate resources efficiently, market price and quantity must be free to adjust to changing market conditions. An **increase in demand** means that consumers are willing to buy more of a good *at every price*; an increase in demand transforms the market equilibrium into excess demand. The excess demand causes the price to rise, and as the price rises, sellers increase their quantity supplied along the supply curve. Equilibrium is restored where the new demand curve intersects the original demand curve. A **decrease in demand** means that consumers wish to purchase less of a commodity at each price (including the former equilibrium price); a decrease in demand transforms market equilibrium into excess supply. The excess supply causes the price to fall until equilibrium is restored where the new demand curve intersects the original supply curve.

An **increase in supply** means that sellers offer more of a commodity for sale at each price, including the former equilibrium price. An increase in supply transforms market equilibrium into **excess supply**. The excess supply decreases the price until equilibrium is restored where the new supply curve intersects the original demand curve. An increase in supply causes equilibrium price to decrease and equilibrium quantity to increase. A **decrease in supply** means that sellers offer less of a commodity for sale at each price, including the former equilibrium price. A decrease in supply transforms market equilibrium into **excess demand**. The excess demand increases the price until equilibrium is achieved where the new supply curve intersects the original demand curve. A decrease in supply increases equilibrium price and decreases equilibrium quantity.

Summary

1. Probably the most useful tool in the economist's analytical tool kit is the theory of supply and demand, which shows how competition among buyers and sellers establishes a stable price.
2. **The law of demand** implies that the quantity of a good that households are willing to buy each time period decreases as the price of that good increases, other factors constant. Some of the other variables that are held constant (influences that cause a change in demand) include household income, the preferences of household members, the prices of substitutes and complements, and the number of households.
3. **The law of supply** implies that the quantity of a good that firms are willing to buy each time period increases as the price of that good increases, other factors constant. Some of the other variables that are held constant (influences that cause a change in supply) include technology, the prices of factors of production, and the number of firms in the market.
4. **Market equilibrium** occurs where **market demand** intersects **market supply**. At that price, there is no tendency for the price to either increase or decrease.
5. **An increase in demand** causes a rightward shift in the demand curve, which leads to an **excess demand** because the quantity demanded exceeds the quantity supplied. The shortage causes the price to rise until the new equilibrium price and quantity are reached along the stationary supply curve.
6. **An increase in supply** causes a rightward shift in the supply curve, which leads to an **excess supply** because the quantity supplied exceeds the quantity demanded. The surplus causes the price to fall until the new equilibrium price and quantity are reached along the stationary demand curve.
7. **Consumer surplus** is the difference between the total value consumers place on a commodity (the area under the demand curve) and the amount they actually pay for the good (price times quantity).
8. **Producer surplus** is the difference between what sellers receive for the good (price times quantity) and total variable costs (the area under the supply curve).
9. A competitive market equilibrium maximizes the sum of consumer and producer surplus.
10. Neither economists nor everyone else can predict financial markets because whenever the supply curve for a financial asset changes, so does the demand curve (and vice versa) because buyers and sellers respond to the same influences.
11. **Rent controls** set maximum rents by law. The consequence is a permanent excess demand for housing. Rent controls are among the major causes of homelessness.
12. **Usury laws** are similar to rent controls in that they set legal limits on interest rates that lenders can charge borrowers. Since market interest rates include premiums for risk, usury laws make it impossible for potential borrowers with the worst credit to obtain legal loans, driving them into underground markets where loan sharks break the legs of delinquent borrowers.

13. **Minimum wage laws** are **price floors,** legal minimum wage rates that employers and employees can agree upon. The result of minimum wage laws is that some unskilled workers lose their jobs and other frustrated job seekers (e.g., high school dropouts) cannot find employment. If the demand for labor is wage inelastic, higher minimum wages will increase the total income of the unskilled, but at the cost of job loss and increased high school dropout rates.
14. If the goal of health care reform is to reduce the price and increase the quantity, then policy should concentrate on increasing supply, rather than subsidizing demand.
15. Because the government is a **monopsony,** it tries to circumvent the laws of supply and demand by drafting reluctant volunteers or surprising reservists when the artificially low pay for military recruits results in a permanent shortage of military personnel.

Glossary

Demand: Refers to the quantity that (potential) buyers are willing and able to buy at alternative prices, given other influences on their behavior including (1) their money income, (2) the number of people in the household, (3) the prices of other goods they might have bought instead, and (4) their tastes and preferences.

Law of demand: Other factors remaining constant, buyers will (try to) purchase less of a commodity at a higher price than they would have purchased at a lower price.

Competitive market: A market in which all buyers and sellers are *price takers* so that the price and quantity are determined by the interaction between supply and demand.

Supply: Refers to the quantity that sellers are willing to sell at each price, other factors (number of firms, prices of factors of production, technology) held constant.

Law of supply: As the price increases, the quantity supplied increases, other factors remaining constant.

Consumer surplus: The area under the demand curve, above the price.

Producer surplus: The area under the price and above the supply curve.

Change in demand: The entire demand curve shifts to right (increase in demand) or to the left (decrease in demand).

Change in supply: The entire supply curve shifts to the right (increase in supply) or to the left (decrease in supply)

Change of quantity demanded: The amount that buyers are willing to purchase changes in response to a price change (a movement along the demand curve).

Change in quantity supplied: The amount that sellers are willing to sell changes in response to a price change (a movement along the supply curve).

Market equilibrium: The price and quantity identified by the intersection of the market demand curve and the market supply curve intersect. At the market equilibrium, there is no tendency for price to change, as it would if there were a shortage (quantity demanded exceeds quantity supplied) or if there were a surplus (quantity supplied exceeds quantity demanded).

Excess demand: A condition when the quantity demanded exceeds the quantity supplied at the prevailing price. Excess demand causes the price to rise until equilibrium is restored. Typically an increase in demand or a decrease in supply causes excess demand.

Excess supply: A condition when the quantity supplied exceeds the quantity demanded at the prevailing price. Excess supply causes the price to fall until equilibrium is restored. Typically an increase in supply or a decrease in demand causes excess supply.

Endogenous variables: The variables determined *inside* the market—price and quantity.

Exogenous variables: The variables determined *outside* the market. For the demand curve, important exogenous variables are number of households, household income, consumer tastes, and the prices of substitutes and complements. For the supply curve, important exogenous variables are number of firms, technology, and prices of factors of production.

Financial markets: markets in which IOUs (bonds) and ownership shares (stocks) are sold, typically among households maintaining financial portfolios.

Rent control: The government enforcement of maximum rents, which cause permanent housing shortages and homelessness.

Usury laws: The government enforcement of maximum interest rates, which causes a shortage of loans to the worst credit risks, driving them to illegal markets, where the consequences of loan default can be physical injury or even death.

Minimum wage laws: The government enforcement of the lowest legal wage rate reduces the employment of the least skilled and may actually encourage high school dropouts to pursue nonexistent jobs.

Employment discrimination: When the market wage is set above the market clearing level, employers or employee associations will have to ration jobs among applicants. When this rationing device is anything except the wage rate, qualified applicants will be turned away, often due to race, gender, or some arbitrary characteristic.