Microeconomic Theory — ECON 323 503
Chapter 2: Supply and Demand

Vikram Manjunath

Texas A&M University

September 9, 2014

Outline

1. Demand: How much do consumers want to buy at a particular price?

Outline

1. Demand: How much do consumers want to buy at a particular price?
2. Supply: How much do firms want to sell at a particular price?

Outline

1. Demand: How much do consumers want to buy at a particular price?
2. Supply: How much do firms want to sell at a particular price?
3. Market Equilibrium: Interaction between the two.

Outline

1. Demand: How much do consumers want to buy at a particular price?
2. Supply: How much do firms want to sell at a particular price?
3. Market Equilibrium: Interaction between the two.
4. Comparative statics: Effects of small changes in the environment.

Outline

1. Demand: How much do consumers want to buy at a particular price?
2. Supply: How much do firms want to sell at a particular price?
3. Market Equilibrium: Interaction between the two.
4. Comparative statics: Effects of small changes in the environment.
5. Elasticity: A handy description of supply or demand.

Outline

6. Effects of a sales tax.

Outline

6. Effects of a sales tax.
7. When supply $\neq$ demand.

Outline

6. Effects of a sales tax.
7. When supply $\neq$ demand.
8. When to (and not to) use this model.

Demand

How much of something do consumers want at a particular price?

Demand

How much of something do consumers want at a particular price?

Depends on (among other things):

1. Information
2. Prices of other things
3. Income
4. Regulations

Demand Function

Demand is a function of the price of the good and all of those other things.

Demand Function

Demand is a function of the price of the good and all of those other things.

Can, for instance, write the following:

$$Q = D(p, p_s, p_c, Y)$$

where

- p is the price of the good that we're studying.
- p_s is the price of a "substitute good."
- p_c is the price of a "complementary good."
- Y is the consumer's income.

An example

The Canadian Pork market.

$$Q = 171 - 20p + 20p_b + 3p_c + 2Y$$

where

- p is the price of pork (\$/kg).
- p_b is the price of beef (a substitute) (\$/kg).
- p_c is the price of chicken (another substitute) (\$/kg).
- Y is the consumer's income (thousand \$/year).

An example

Suppose we know that $p_b = \$4, p_c = \$3\frac{1}{3}$, and $Y = 12.5$

An example

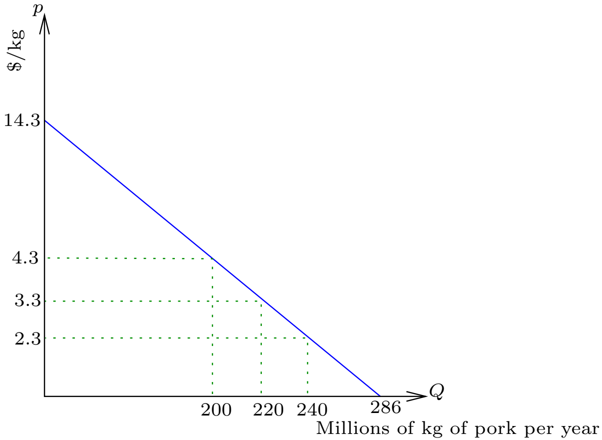
Suppose we know that $p_b = \$4, p_c = \$3\frac{1}{3}$, and $Y = 12.5$

Then,

$$Q = 286 - 20p = D(p).$$

Graphically

The *demand curve*:



Convention: p on the vertical and Q on the horizontal axis.

What happens when the price changes?

As the price increases, quantity demanded decreases.

What happens when the price changes?

As the price increases, quantity demanded decreases.

This is the Law of Demand.

What happens when the price changes?

As the price increases, quantity demanded decreases.

This is the Law of Demand.

Two equivalent ways to say this:

1. The demand curve slopes downwards.
2. $\frac{dQ}{dp} < 0$.

What happens when the price changes?

As the price increases, quantity demanded decreases.

This is the Law of Demand.

Two equivalent ways to say this:

1. The demand curve slopes downwards.
2. $\frac{dQ}{dp} < 0$.

But we move *along* the demand curve.

What if other things change?

Changes in prices of other goods, income, regulations, etc. affect the quantity demanded.

They cause the entire demand curve to shift up or down.

Pork example

Suppose that the price of beef rises to \$4.60 a kg.

Pork example

Suppose that the price of beef rises to \$4.60 a kg.
New demand curve is given by

$$D(p) = 298 - 20p.$$

Pork example

Suppose that the price of beef rises to \$4.60 a kg.
New demand curve is given by

$$D(p) = 298 - 20p.$$

What happened to its slope?

Pork example

Suppose that the price of beef rises to \$4.60 a kg.
New demand curve is given by

$$D(p) = 298 - 20p.$$

What happened to its slope? It didn't change.

Pork example

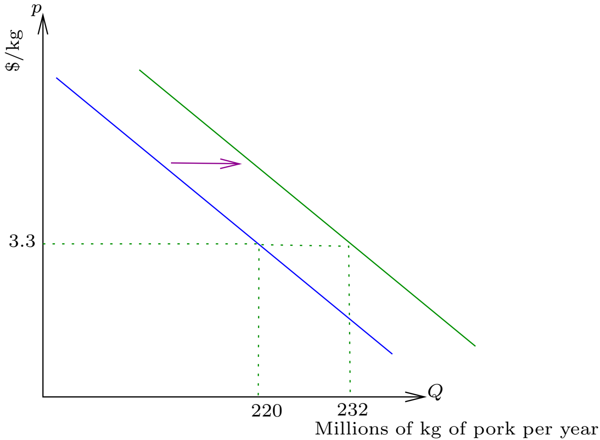
Suppose that the price of beef rises to \$4.60 a kg.
New demand curve is given by

$$D(p) = 298 - 20p.$$

What happened to its slope? It didn't change.

But the curve itself shifted upwards: if beef is more expensive, people buy more pork.

Graphically



Summing Demand Functions

Suppose that Ann's demand function is D_A and Bob's demand function is D_B. What is their total demand?

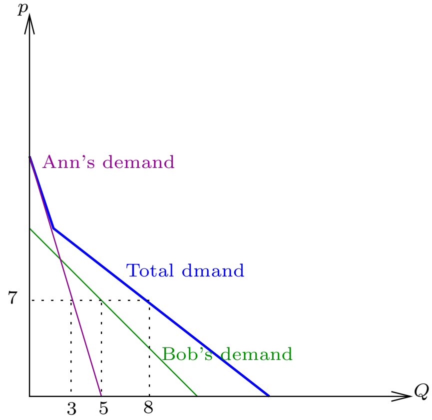
Summing Demand Functions

Suppose that Ann's demand function is D_A and Bob's demand function is D_B. What is their total demand?
Just add them up:

$$Q = Q_A + Q_B = D_A(p) + D_B(p).$$

Summing Demand Curves

We add the demand curve horizontally.



Supply

How much of something do firms want to sell at a particular price?

Supply

How much of something do firms want to sell at a particular price?

Depends on

1. Production costs
2. Regulations

Supply function

Supply is a function of the price of the good as well as the prices of inputs.

Supply function

Supply is a function of the price of the good as well as the prices of inputs.

Sticking with the pork example,

$$Q = S(p, p_h)$$

where p_h is the price of hogs (\$/kg).

Supply function

Supply is a function of the price of the good as well as the prices of inputs.

Sticking with the pork example,

$$Q = S(p, p_h)$$

where p_h is the price of hogs ($/kg).

Based on one study,

$$Q = 178 + 40p - 60p_h.$$

Supply function

Supply is a function of the price of the good as well as the prices of inputs.

Sticking with the pork example,

$$Q = S(p, p_h)$$

where p_h is the price of hogs ($/kg).

Based on one study,

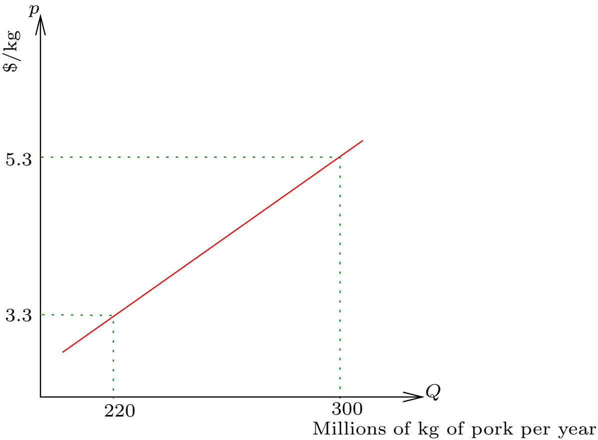
$$Q = 178 + 40p - 60p_h.$$

If $p_h = 1.5$,

$$Q = 88 + 40p.$$

Graphically

The *supply curve*:



Changes

Changes in the price: Typically supply increases with the price (but there's no "Law of Supply"). Movement is *along* the supply curve.

Changes

Changes in the price: Typically supply increases with the price (but there's no "Law of Supply"). Movement is *along* the supply curve.

Changes in other things: In our example, the price of hogs could change. This would shift the entire supply curve.

Changes

Changes in the price: Typically supply increases with the price (but there's no "Law of Supply"). Movement is *along* the supply curve.

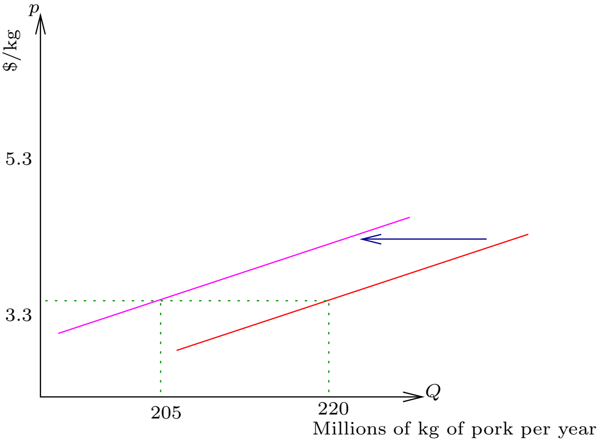
Changes in other things: In our example, the price of hogs could change. This would shift the entire supply curve.

If the price of hogs increases to \$1.75,

$$Q = 73 + 40p$$

Since the price of hogs goes up, the supply curve shifts left: If hogs are more expensive, firms need a higher price to supply the same amount of pork.

Shifting supply curves



Summing Supply Functions

S^D: Japanese domestic supply of rice.

S^F: Foreign supply of rice.
Total supply is just

$$Q = Q^D + Q^F = S^D(p) + S^F(p).$$

Summing Supply Functions

S^D: Japanese domestic supply of rice.

S^F: Foreign supply of rice.
Total supply is just

$$Q = Q^D + Q^F = S^D(p) + S^F(p).$$

One way the government could affect the total supply is by choosing to ban imports. Then the total supply would be described by S^D rather than $S^D + S^F$.

Market Equilibrium

You've heard it a million times:

Demand equals supply.

Market Equilibrium

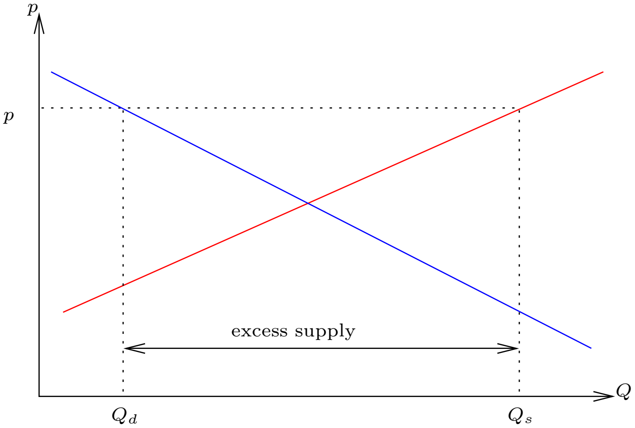
You've heard it a million times:

Demand equals supply.

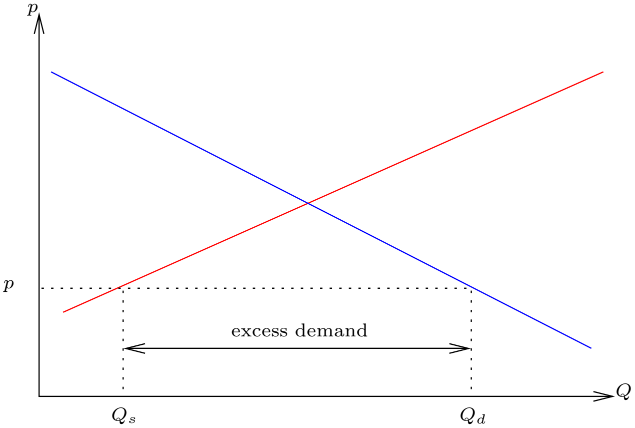
This is the concept of an equilibrium: no participant wants to change his behavior.

Consumers want to buy the same quantity that firms want to sell.

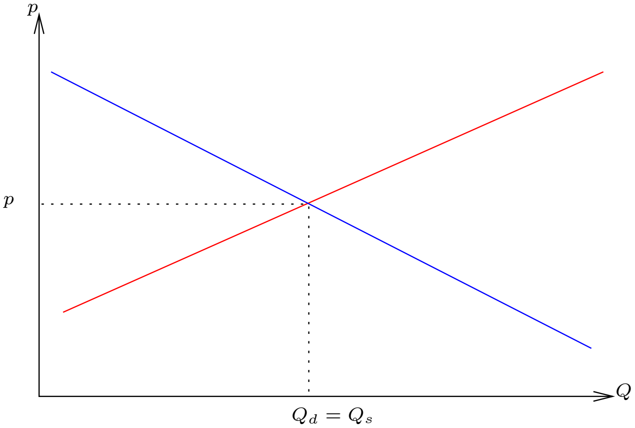
Where is the equilibrium?



Where is the equilibrium?



Where is the equilibrium?



An example

$$\begin{aligned} Q_d &= 286 - 20p \\ Q_s &= 88 + 40p \end{aligned}$$

Need to find$p$ where $Q_d = Q_s$.

An example

$$\begin{aligned} Q_d &= 286 - 20p \\ Q_s &= 88 + 40p \end{aligned}$$

Need to find$p$ where $Q_d = Q_s$.

Setting $Q_d = Q_s$:

$$286 - 20p = 88 + 40p.$$

So we find that $p = \$3.30$.

How do we get to equilibrium?

Every actor behaves independently. Yet we get to an equilibrium. How?

How do we get to equilibrium?

Every actor behaves independently. Yet we get to an equilibrium. How?

Adam Smith's *invisible hand* is how.

How do we get to equilibrium?

Every actor behaves independently. Yet we get to an equilibrium. How?

Adam Smith's *invisible hand* is how.

If the price is too high, sellers can't find enough buyers. They'd have to dispose (or store) their wares and incur a cost. This would lead to a change in their choice of how much to supply.

How do we get to equilibrium?

Every actor behaves independently. Yet we get to an equilibrium. How?

Adam Smith's *invisible hand* is how.

If the price is too high, sellers can't find enough buyers. They'd have to dispose (or store) their wares and incur a cost. This would lead to a change in their choice of how much to supply.

If the price is too low, buyers can't find enough sellers. Some buyers would offer more than that price to get what they want.

How do we get to equilibrium?

Every actor behaves independently. Yet we get to an equilibrium. How?

Adam Smith's *invisible hand* is how.

If the price is too high, sellers can't find enough buyers. They'd have to dispose (or store) their wares and incur a cost. This would lead to a change in their choice of how much to supply.

If the price is too low, buyers can't find enough sellers. Some buyers would offer more than that price to get what they want.

When the price is *just* right, nobody changes their behavior.

Comparative statics

Compare what happens before and after a change to something in the environment, like a change in the price of hogs.

Comparative statics

Compare what happens before and after a change to something in the environment, like a change in the price of hogs.

Suppose the price of hogs increases from \$1.50 to \$1.75.
What is the effect on the equilibrium?

Comparative statics

Compare what happens before and after a change to something in the environment, like a change in the price of hogs.

Suppose the price of hogs increases from \$1.50 to \$1.75. What is the effect on the equilibrium?

Original equilibrium price was \$3.30 with consumers demanding 220 million kg. But supply is only 205. The price is too low.

Comparative statics

Compare what happens before and after a change to something in the environment, like a change in the price of hogs.

Suppose the price of hogs increases from \$1.50 to \$1.75. What is the effect on the equilibrium?

Original equilibrium price was \$3.30 with consumers demanding 220 million kg. But supply is only 205. The price is too low.

Equating supply and demand, we find the new equilibrium price of \$3.55 and quantity of 215 million kg.

Comparative statics

Compare what happens before and after a change to something in the environment, like a change in the price of hogs.

Suppose the price of hogs increases from \$1.50 to \$1.75. What is the effect on the equilibrium?

Original equilibrium price was \$3.30 with consumers demanding 220 million kg. But supply is only 205. The price is too low.

Equating supply and demand, we find the new equilibrium price of \$3.55 and quantity of 215 million kg.

So the increase in p_h cause and increase in the equilibrium price and a decrease in the equilibrium quantity.

Small changes

Here, we can use some calculus so that we don't have to actually calculate and recalculate the equilibrium.

Small changes

Here, we can use some calculus so that we don't have to actually calculate and recalculate the equilibrium.

Suppose supply depends on the environmental variable a:

$$S(p, a).$$

Demand doesn't: $D(p)$.

Small changes

Here, we can use some calculus so that we don't have to actually calculate and recalculate the equilibrium.

Suppose supply depends on the environmental variable a:

$$S(p, a).$$

Demand doesn't: $D(p)$.

Equilibrium price solves

$$S(p, a) = D(p).$$

This solution is a function of a. Call it $p(a)$.

Small changes

Here, we can use some calculus so that we don't have to actually calculate and recalculate the equilibrium.

Suppose supply depends on the environmental variable a:

$$S(p, a).$$

Demand doesn't: $D(p)$.

Equilibrium price solves

$$S(p, a) = D(p).$$

This solution is a function of a. Call it $p(a)$.

So, the equilibrium condition is actually

$$S(p(a), a) = D(p(a)).$$

Small changes

Using the "chain rule":

$$\frac{dD(p(a))}{dp}\frac{dp}{da} = \frac{\delta S(p(a),a)}{\delta p}\frac{dp}{da} + \frac{\delta S(p(a),a)}{\delta a}.$$

Small changes

Using the "chain rule":

$$\frac{dD(p(a))}{dp}\frac{dp}{da} = \frac{\delta S(p(a),a)}{\delta p}\frac{dp}{da} + \frac{\delta S(p(a),a)}{\delta a}.$$

Rearranging this:

$$\frac{dp}{da} = \frac{\frac{\delta S}{\delta a}}{\frac{dD}{dp} - \frac{\delta S}{\delta p}}.$$

Small changes

Using the "chain rule":

$$\frac{dD(p(a))}{dp}\frac{dp}{da} = \frac{\delta S(p(a),a)}{\delta p}\frac{dp}{da} + \frac{\delta S(p(a),a)}{\delta a}.$$

Rearranging this:

$$\frac{dp}{da} = \frac{\frac{\delta S}{\delta a}}{\frac{dD}{dp} - \frac{\delta S}{\delta p}}.$$

Since $\frac{dD}{dp} < 0$, if $\frac{\delta S}{\delta p} > 0$, then $\frac{dp}{da}$ has the opposite sign as $\frac{\delta S}{\delta a}$.

Small changes

Using the "chain rule":

$$\frac{dD(p(a))}{dp}\frac{dp}{da} = \frac{\delta S(p(a),a)}{\delta p}\frac{dp}{da} + \frac{\delta S(p(a),a)}{\delta a}.$$

Rearranging this:

$$\frac{dp}{da} = \frac{\frac{\delta S}{\delta a}}{\frac{dD}{dp} - \frac{\delta S}{\delta p}}.$$

Since $\frac{dD}{dp} < 0$, if $\frac{\delta S}{\delta p} > 0$, then $\frac{dp}{da}$ has the opposite sign as $\frac{\delta S}{\delta a}$.

We can also differentiate $Q = D(p(a)$ to see that

$$\frac{dQ}{da} = \frac{dD}{dp}\frac{dp}{da}.$$

Small changes

Using the "chain rule":

$$\frac{dD(p(a))}{dp}\frac{dp}{da} = \frac{\delta S(p(a),a)}{\delta p}\frac{dp}{da} + \frac{\delta S(p(a),a)}{\delta a}.$$

Rearranging this:

$$\frac{dp}{da} = \frac{\frac{\delta S}{\delta a}}{\frac{dD}{dp} - \frac{\delta S}{\delta p}}.$$

Since $\frac{dD}{dp} < 0$, if $\frac{\delta S}{\delta p} > 0$, then $\frac{dp}{da}$ has the opposite sign as $\frac{\delta S}{\delta a}$.

We can also differentiate $Q = D(p(a)$ to see that

$$\frac{dQ}{da} = \frac{dD}{dp}\frac{dp}{da}.$$

Since $\frac{dD}{dp} < 0, \frac{dQ}{da}$ has the opposite sign as $\frac{dp}{da}$.

How big are the changes?

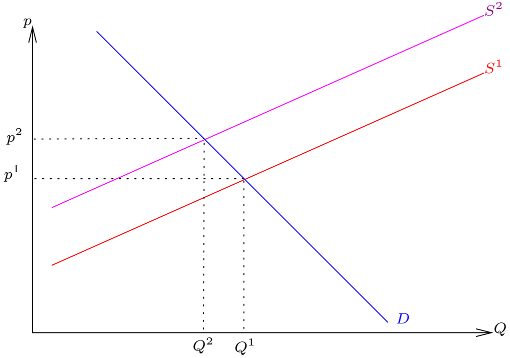
The comparative statics that we just saw usually tell us the sign of the effect. But the magnitude depends on the shape of the supply and demand curves.

Say the supply curve shifts left.

How big are the changes?

The comparative statics that we just saw usually tell us the sign of the effect. But the magnitude depends on the shape of the supply and demand curves.

Say the supply curve shifts left.

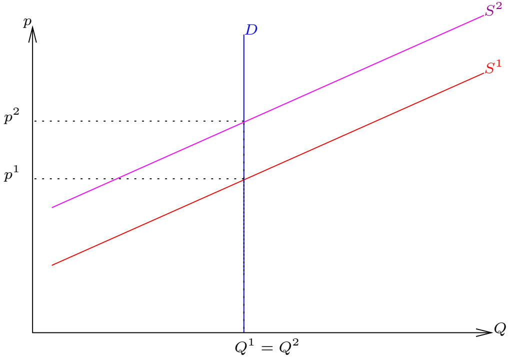


Q decreases and p increases.

How big are the changes?

The comparative statics that we just saw usually tell us the sign of the effect. But the magnitude depends on the shape of the supply and demand curves.

Say the supply curve shifts left.

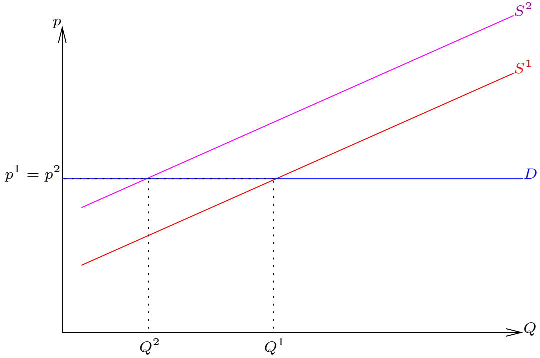


Steeper the demand curve, smaller the change.

How big are the changes?

The comparative statics that we just saw usually tell us the sign of the effect. But the magnitude depends on the shape of the supply and demand curves.

Say the supply curve shifts left.



Flatter the demand curve, bigger the change.

Elasticity

How does demand respond to a change in the price?

Elasticity

How does demand respond to a change in the price?

The Law of Demand says that it decreases.

Elasticity

How does demand respond to a change in the price?

The Law of Demand says that it decreases.

But is there a nice way to summarize by how much?

Elasticity

How does demand respond to a change in the price?

The Law of Demand says that it decreases.

But is there a nice way to summarize by how much?

Elasticity of demand: percentage change in demand for a 1% change in price:

$$\varepsilon = \frac{\frac{\Delta Q}{Q}}{\frac{\Delta P}{P}} = \frac{\delta Q}{\delta p}\frac{p}{Q}.$$

Elasticity

How does demand respond to a change in the price?

The Law of Demand says that it decreases.

But is there a nice way to summarize by how much?

Elasticity of demand: percentage change in demand for a 1% change in price:

$$\varepsilon = \frac{\frac{\Delta Q}{Q}}{\frac{\Delta P}{P}} = \frac{\delta Q}{\delta p}\frac{p}{Q}.$$

If $\varepsilon = -2$, then a 1% increase in price leads to a -2% increase in demand (or, more reasonably, a 2% decrease).

Calculating elasticity

$$Q = a - bp$$

Calculating elasticity

$$Q = a - bp$$

$$\varepsilon = \frac{dQ}{dp}\frac{p}{Q} = -b\frac{p}{Q}$$

Calculating elasticity

$$Q = a - bp$$

$$\varepsilon = \frac{dQ}{dp}\frac{p}{Q} = -b\frac{p}{Q}$$

For our pork example, $a = 286$ and $b = 20$ so at $p = \$3.30$ and $Q = 220$, $\varepsilon = -20 \times \frac{3.30}{220} = -0.3$

Moving along the demand curve

What happens to elasticity as we move along the demand curve?

Moving along the demand curve

What happens to elasticity as we move along the demand curve?
For the demand curve we just saw, it depends on p and Q.

Moving along the demand curve

What happens to elasticity as we move along the demand curve? For the demand curve we just saw, it depends on p and Q.

If $p = 0$, then $\varepsilon = 0$: demand is *perfectly inelastic*. Changes in price don't affect demand any further.

Moving along the demand curve

What happens to elasticity as we move along the demand curve? For the demand curve we just saw, it depends on p and Q.

If $p = 0$, then $\varepsilon = 0$: demand is *perfectly inelastic*. Changes in price don't affect demand any further.

If $Q = 0$, then $\varepsilon = -\infty$: demand is *perfectly elastic*. Any increase in price drops demand to zero.

Moving along the demand curve

Moving between these two extreme points we have every possible value between 0 and $-\infty$.

Moving along the demand curve

Moving between these two extreme points we have every possible value between 0 and $-\infty$.

Unitary elasticity: $\varepsilon = -1$. The percentage change in demand is the same as the percentage change in price.

This happens when $p = \frac{a}{2b}$ and $Q = a2$

Moving along the demand curve

Moving between these two extreme points we have every possible value between 0 and $-\infty$.
Unitary elasticity: $\varepsilon = -1$. The percentage change in demand is the same as the percentage change in price.
This happens when $p = \frac{a}{2b}$ and $Q = a2$

Elastic demand: $\varepsilon < -1$. The percentage change in demand is more than the percentage change in price.
This happens to the left of unitary elasticity.

Moving along the demand curve

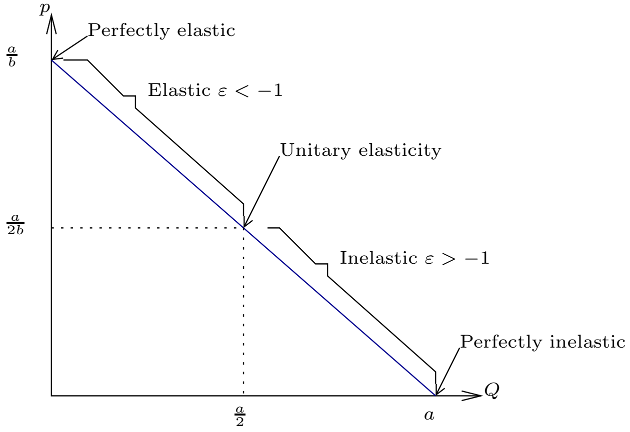
Moving between these two extreme points we have every possible value between 0 and $-\infty$.

Unitary elasticity: $\varepsilon = -1$. The percentage change in demand is the same as the percentage change in price.
This happens when $p = \frac{a}{2b}$ and $Q = a2$

Elastic demand: $\varepsilon < -1$. The percentage change in demand is more than the percentage change in price.
This happens to the left of unitary elasticity.

Inelastic demand: $\varepsilon > -1$. The percentage change in demand is less than the percentage change in price.
This happens to the right unitary elasticity.

Moving along the demand curve



Can elasticity be constant?

$$Q = Ap^{\varepsilon}$$

Elasticity is ε no matter p and Q.

Can elasticity be constant?

$$Q = Ap^{\varepsilon}$$

Elasticity is ε no matter p and Q.

If the demand curve is a horizontal line, demand is perfectly elastic everywhere.
This happens when a good has a perfect substitute: if the price rises, everyone just switches to the other good.

Can elasticity be constant?

$$Q = Ap^{\varepsilon}$$

Elasticity is ε no matter p and Q.

If the demand curve is a horizontal line, demand is perfectly elastic everywhere.
This happens when a good has a perfect substitute: if the price rises, everyone just switches to the other good.

If the demand curve is a vertical line, demand is perfectly inelastic everywhere.
This happens when a good is *essential*: you can't live without it.

Other demand elasticities

What we saw is actually called the “price elasticity” of demand.

But we can just as well define

1. Income elasticity: percentage change in demand for a 1% increase in income.

Other demand elasticities

What we saw is actually called the “price elasticity” of demand.

But we can just as well define

1. Income elasticity: percentage change in demand for a 1% increase in income.
2. Cross-price elasticity: percentage change in demand for a 1% increase in the price of another good. This is relevant for substitutes and complements.

Supply elasticity

$$\eta = \frac{\text{\% change in supply}}{\text{\% change in price}} = \frac{\frac{\Delta Q}{Q}}{\frac{\Delta p}{p}} = \frac{\delta Q}{\delta p}\,\frac{p}{Q}.$$

Supply elasticity

$$\eta = \frac{\%\text{ change in supply}}{\%\text{ change in price}} = \frac{\frac{\Delta Q}{Q}}{\frac{\Delta p}{p}} = \frac{\delta Q}{\delta p}\frac{p}{Q}.$$

For the Pork example: $Q = 88 + 40p$ so at $p = \$3.30$ and $Q = 220$,

$$\eta = \frac{\delta Q}{\delta p}\frac{p}{Q} = 40 \times \frac{3.30}{220} = 0.6.$$

Supply elasticity

$$\eta = \frac{\%\text{ change in supply}}{\%\text{ change in price}} = \frac{\frac{\Delta Q}{Q}}{\frac{\Delta p}{p}} = \frac{\delta Q}{\delta p}\frac{p}{Q}.$$

For the Pork example: $Q = 88 + 40p$ so at $p = \$3.30$ and $Q = 220$,

$$\eta = \frac{\delta Q}{\delta p}\frac{p}{Q} = 40 \times \frac{3.30}{220} = 0.6.$$

Unlike demand elasticity, supply elasticity is positive valued (except in the rare case where the supply curve slopes downwards).

Moving along the supply curve

Elasticity varies along the supply curve: it depends on $\frac{p}{Q}$.

Moving along the supply curve

Elasticity varies along the supply curve: it depends on $\frac{p}{Q}$.

- $\eta = 0$: perfectly inelastic supply.
- $0 < \eta < 1$: inelastic supply.
- $1 < \eta$: elastic supply
- $\eta = \infty$: perfectly elastic supply.

Elasticity over time

Whether elasticity is greater over the long or short run depends on how easily the good is replaced.

Elasticity over time

Whether elasticity is greater over the long or short run depends on how easily the good is replaced.

- An electric car isn't a good substitute for a gas car in the short run, but it is in the long run.
- A mac is a good substitue for a PC in the short run, but once you get "locked in" it's not a good substitute.

Elasticity over time

Whether elasticity is greater over the long or short run depends on how easily the good is replaced.

- An electric car isn't a good substitute for a gas car in the short run, but it is in the long run.
- A mac is a good substitue for a PC in the short run, but once you get "locked in" it's not a good substitute.

The easier it is to substitute a good, the more elastic demand will be.

Elasticity over time

Whether elasticity is greater over the long or short run depends on how easily the good is replaced.

- An electric car isn't a good substitute for a gas car in the short run, but it is in the long run.
- A mac is a good substitue for a PC in the short run, but once you get "locked in" it's not a good substitute.

The easier it is to substitute a good, the more elastic demand will be.

Similar reasoning applies to supply elasticity.

Effects of a sales tax

Two types of tax:

1. *Ad valorem* tax: a percentage of the sales price. If the price of an apple is p, you pay $(1+\alpha)p$ where α is the tax rate. This is the most common form.
2. *Unit or specific* tax: the tax doesn't depend on the sales price. If the price of an apple is p, you pay $p+\tau$ where τ is the tax rate. E.g. federal tax on gasoline.

Effect of tax on equilibrium

Specific tax: τ.

Effect of tax on equilibrium

Specific tax: τ.

Consumer pays $p \longrightarrow \tau$ to government and $p - \tau$ to supplier.

Effect of tax on equilibrium

Specific tax: τ.

Consumer pays $p \longrightarrow \tau$ to government and $p - \tau$ to supplier.

Since supplier only gets $p - \tau$ at price p, supply curve shifts left.

An example

Canadian pork: Suppose $\tau = \$1.05$ per kg.

An example

Canadian pork: Suppose $\tau = \$1.05$ per kg.

Without tax: at price \$2.95, supply of 206 million kg.

An example

Canadian pork: Suppose $\tau = \$1.05$ per kg.

Without tax: at price \$2.95, supply of 206 million kg.

After tax, supplier only gets \$1.90 so the supply is less.

An example

Canadian pork: Suppose $\tau = \$1.05$ per kg.

Without tax: at price \$2.95, supply of 206 million kg.

After tax, supplier only gets \$1.90 so the supply is less.

At what price does the firm supply 206 million kg? Needs to receive \$2.95, so price needs to be $\$2.95 + \tau = \$4.00$.

An example

Canadian pork: Suppose $\tau = \$1.05$ per kg.

Without tax: at price \$2.95, supply of 206 million kg.

After tax, supplier only gets \$1.90 so the supply is less.

At what price does the firm supply 206 million kg? Needs to receive \$2.95, so price needs to be $\$2.95 + \tau = \$4.00$.

Supply curve shifts left (up) by τ.

An example

Canadian pork: Suppose $\tau = \$1.05$ per kg.

Without tax: at price \$2.95, supply of 206 million kg.

After tax, supplier only gets \$1.90 so the supply is less.

At what price does the firm supply 206 million kg? Needs to receive \$2.95, so price needs to be $\$2.95 + \tau = \$4.00$.

Supply curve shifts left (up) by τ.

Equilibrium price goes up, equilibrium quantity goes down.

An example

Canadian pork: Suppose $\tau = \$1.05$ per kg.

Without tax: at price \$2.95, supply of 206 million kg.

After tax, supplier only gets \$1.90 so the supply is less.

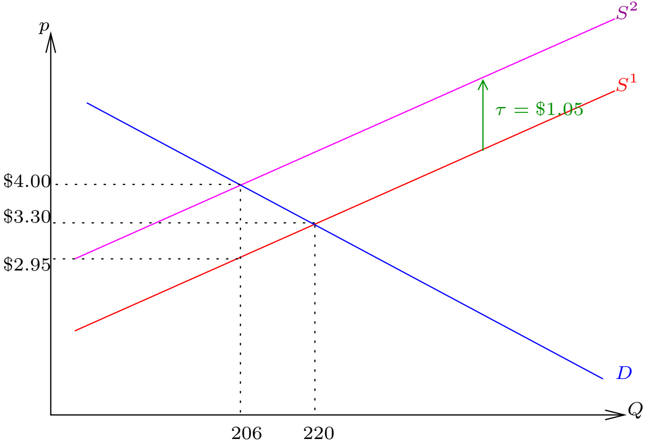
At what price does the firm supply 206 million kg? Needs to receive \$2.95, so price needs to be $\$2.95 + \tau = \$4.00$.

Supply curve shifts left (up) by τ.

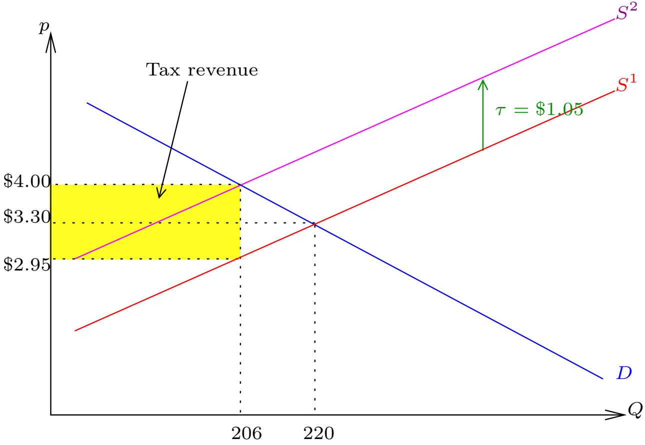
Equilibrium price goes up, equilibrium quantity goes down.

We'll see that the elasticity determines by how much.

Graphically



Graphically



Tax revenue = τQ= \$216.3 million.

Who's really paying the tax?

What we want to know is this: how much does the *price* change because of the tax? In the example, price only changed by \$0.70=\$4.00 - \$3.30 even though tax was \$1.05.

Who's really paying the tax?

What we want to know is this: how much does the *price* change because of the tax? In the example, price only changed by \$0.70=\$4.00 - \$3.30 even though tax was \$1.05.

What we really want is: $\frac{dp}{d\tau}$.

Who's really paying the tax?

What we want to know is this: how much does the *price* change because of the tax? In the example, price only changed by \$0.70=\$4.00 - \$3.30 even though tax was \$1.05.

What we really want is: $\frac{dp}{d\tau}$.

Equilibrium condition *with* tax:

$$D(p) = S(p - \tau).$$

Who's really paying the tax?

What we want to know is this: how much does the *price* change because of the tax? In the example, price only changed by \$0.70=\$4.00 - \$3.30 even though tax was \$1.05.

What we really want is: $\frac{dp}{d\tau}$.

Equilibrium condition *with* tax:

$$D(p) = S(p - \tau).$$

The equilibrium price is a function of the tax: $p(\tau)$. So we can write the equilibrium condition as

$$D(p(\tau)) = S(p(\tau) - \tau).$$

Who's really paying the tax?

Differentiating this with respect to τ

$$\frac{dD}{dp}\frac{dp}{d\tau} = \frac{dS}{dp}\frac{d(p(\tau)-\tau)}{d\tau} = \frac{dS}{dp}\left(\frac{dp}{d\tau} - 1\right).$$

Who's really paying the tax?

Differentiating this with respect to τ

$$\frac{dD}{dp}\frac{dp}{d\tau} = \frac{dS}{dp}\frac{d(p(\tau)-\tau)}{d\tau} = \frac{dS}{dp}\left(\frac{dp}{d\tau} - 1\right).$$

Rearranging this,

$$\frac{dp}{d\tau} = \frac{\frac{dS}{dp}}{\frac{dS}{dp} - \frac{dD}{dp}}.$$

Who's really paying the tax?

Differentiating this with respect to τ

$$\frac{dD}{dp}\frac{dp}{d\tau} = \frac{dS}{dp}\frac{d(p(\tau)-\tau)}{d\tau} = \frac{dS}{dp}\left(\frac{dp}{d\tau} - 1\right).$$

Rearranging this,

$$\frac{dp}{d\tau} = \frac{\frac{dS}{dp}}{\frac{dS}{dp} - \frac{dD}{dp}}.$$

We know the sign of this: $\frac{dD}{dp} < 0$ and $\frac{dS}{dp} > 0$ so $\frac{dp}{d\tau} > 0$. This means that the price increases with tax.

Who's really paying the tax?

Differentiating this with respect to τ

$$\frac{dD}{dp}\frac{dp}{d\tau} = \frac{dS}{dp}\frac{d(p(\tau)-\tau)}{d\tau} = \frac{dS}{dp}\left(\frac{dp}{d\tau} - 1\right).$$

Rearranging this,

$$\frac{dp}{d\tau} = \frac{\frac{dS}{dp}}{\frac{dS}{dp} - \frac{dD}{dp}}.$$

We know the sign of this: $\frac{dD}{dp} < 0$ and $\frac{dS}{dp} > 0$ so $\frac{dp}{d\tau} > 0$. This means that the price increases with tax.

The exact rate at which it increases depends on elasticities: Multiplying numerator and denominator by $\frac{p}{Q}$,

$$\frac{dp}{d\tau} = \frac{\frac{dS}{dp}\frac{p}{Q}}{\frac{dS}{dp}\frac{p}{Q} - \frac{dD}{dp}\frac{p}{Q}} = \frac{\eta}{\eta - \varepsilon}.$$

Who's really paying the tax?

Now we can really answer this question:

1. *Incidence of tax on consumers:* $\frac{dp}{d\tau}$.
2. *Incidence of tax on suppliers:* $1 - \frac{dp}{d\tau}$.

What if we made the consumers pay instead of the suppliers?

Again, specific tax: τ.

Consumer pays $p + \tau \to \tau$ to government and p to supplier

Supplier gets p.

Since, at price p, consumer pays $p + t$, demand curve shifts down.

Equilibrium condition is

$$D(p + \tau) = S(p).$$

For the pork example solving this, $p = \$2.95$.

What if we made the consumers pay instead of the suppliers?

Again, specific tax: τ.

Consumer pays $p + \tau \to \tau$ to government and p to supplier

Supplier gets p.

Since, at price p, consumer pays $p + t$, demand curve shifts down.

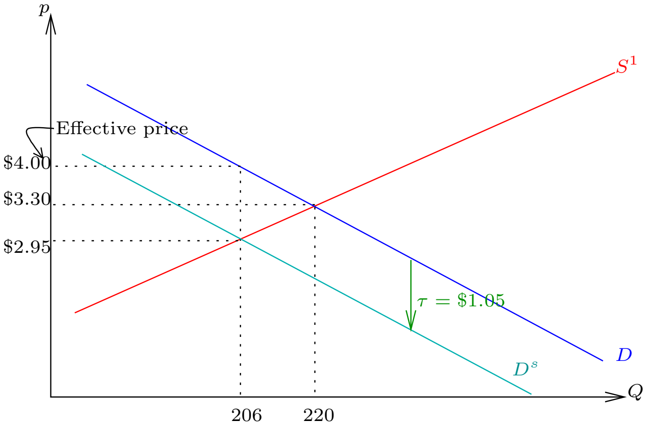
Equilibrium condition is

$$D(p + \tau) = S(p).$$

For the pork example solving this, $p = \$2.95$.

Nothing changed! The consumer still pays $\$4 (= p + \tau)$.

Consumers paying the tax



What about *ad valorem* tax?

The tax that consumers pay per unit is $\alpha = \frac{\tau}{p} = \frac{1.05}{3.30} = 26.25\%$.

What about *ad valorem* tax?

The tax that consumers pay per unit is $\alpha = \frac{\tau}{p} = \frac{1.05}{3.30} = 26.25\%$.

What if we replaced the specific tax τ with an ad valorem tax α?

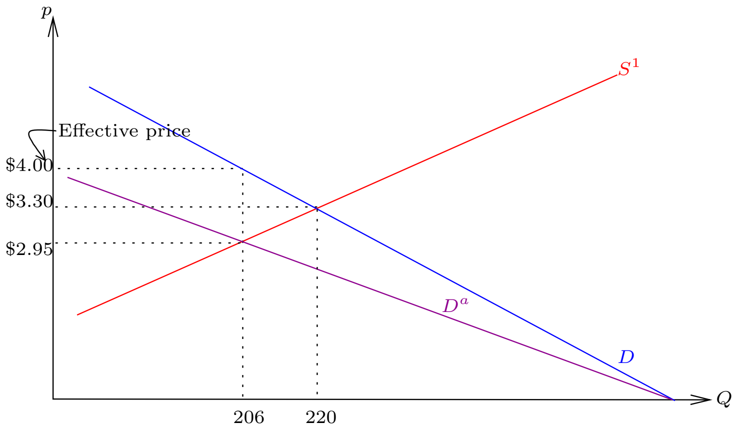
What about *ad valorem* tax?

The tax that consumers pay per unit is $\alpha = \frac{\tau}{p} = \frac{1.05}{3.30} = 26.25\%$.

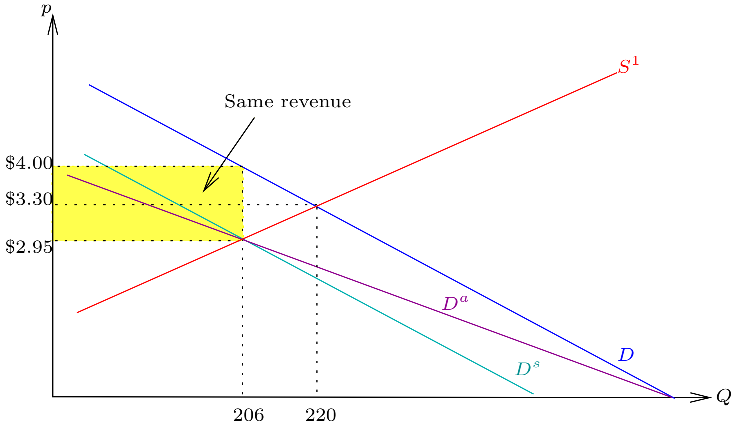
What if we replaced the specific tax τ with an ad valorem tax α?

The demand curve D^a would rotate, gap between D and D^a being αp.

Graphically



Ad valorem vs unit tax



When supply $\neq$ demand

Sometimes, demand (what consumers *want to buy* at a particular price) and supply (what firms *want to sell* at a particular price) may differ.

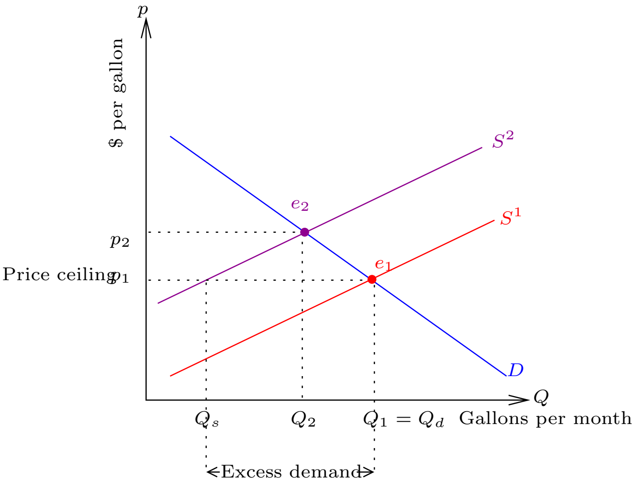
This may happen because of certain kinds of government interventions like price controls.

1. Price ceiling: price is legally required to be below a certain threshold $\overline{p}$. Example: gas prices in the 1970s, rent control in NYC.
2. Price floor: price is legally required to be above a certain threshold $\overline{p}$. Example: minimum wage

Example of price ceiling

Oil supply is reduced: supply curve shifts left.
Equilibrium price goes from $p_1 = \$5$ to $p_2 = \$6$.
Government outlaws a price increase: prices cannot exceed $\overline{p} = \$5$.
Does quantity demand equal quantity supplied?

Gasoline price ceiling



When to use this model

Some key assumptions (limitations) of the model:

1. There are many identical firms and consumers: nobody can affect the price on their own.

When to use this model

Some key assumptions (limitations) of the model:

1. There are many identical firms and consumers: nobody can affect the price on their own.
2. Everyone has full information: everyone knows all prices and characteristics of goods.

When to use this model

Some key assumptions (limitations) of the model:

1. There are many identical firms and consumers: nobody can affect the price on their own.
2. Everyone has full information: everyone knows all prices and characteristics of goods.
3. There are no transaction costs.

When to use this model

Some key assumptions (limitations) of the model:

1. There are many identical firms and consumers: nobody can affect the price on their own.
2. Everyone has full information: everyone knows all prices and characteristics of goods.
3. There are no transaction costs.
4. Firms can easily enter and exit the market.

When to use this model

These assumptions actually *seldom* hold in reality. Examples of violations:

1. Small/identical firms and consumers: utilities, artists

When to use this model

These assumptions actually *seldom* hold in reality. Examples of violations:

1. Small/identical firms and consumers: utilities, artists
2. Full information: used cars

When to use this model

These assumptions actually *seldom* hold in reality. Examples of violations:

1. Small/identical firms and consumers: utilities, artists
2. Full information: used cars
3. There are no transaction costs: broker's fees

When to use this model

These assumptions actually *seldom* hold in reality. Examples of violations:

1. Small/identical firms and consumers: utilities, artists
2. Full information: used cars
3. There are no transaction costs: broker's fees
4. Firms can easily enter and exit the market: almost all manufacturing

Solution of problem 5.8 from the textbook

Demand function for coconut oil:

$$Q = 1,200 - 9.5p + 16.2p_p + 0.2Y$$

where

Q	—	Quantity demanded (1,000s of metric tons)
p	—	price of coconut oil (¢/lb)
p_p	—	price of palm oil (¢/lb)
Y	—	consumer's income

Calculate price and cross-price elasticity of the demand for coconut oil at $p = 45$¢/lb, $p_p = 31$¢/lb, and $Q = 1,275$ thousand metric tons.

Solution of problem 5.8: price elasticity

1. Express demand as a function of p: Substituting value of p_p

   $Q = 1,200 - 9.5p + 16.2 \times 31 + 0.2Y = 1702.2 + 0.2Y - 9.5p$

Solution of problem 5.8: price elasticity

1. Express demand as a function of p: Substituting value of p_p

   $Q = 1,200 - 9.5p + 16.2 \times 31 + 0.2Y = 1702.2 + 0.2Y - 9.5p$

2. So $\frac{dQ}{dp} = -9.5$

Solution of problem 5.8: price elasticity

1. Express demand as a function of p: Substituting value of p_p

   $$Q = 1,200 - 9.5p + 16.2 \times 31 + 0.2Y = 1702.2 + 0.2Y - 9.5p$$

2. So $\frac{dQ}{dp} = -9.5$
3. $\varepsilon = \frac{dQ}{dp}\frac{p}{Q} = (-9.5) \times \frac{45}{1{,}275} \approx -0.34.$

Solution of problem 5.8: price elasticity

1. Express demand as a function of p: Substituting value of p_p

   $$Q = 1,200 - 9.5p + 16.2 \times 31 + 0.2Y = 1702.2 + 0.2Y - 9.5p$$

2. So $\frac{dQ}{dp} = -9.5$
3. $\varepsilon = \frac{dQ}{dp}\frac{p}{Q} = (-9.5) \times \frac{45}{1{,}275} \approx -0.34.$

So a <u>1% increase</u> in the price of coconut oil leads to about a <u>0.34% decrease</u> in demand for it.

Solution of problem 5.8: cross-price elasticity

1. Express demand as a function of p_p: Substituting value of p

   $Q = 1,200 - 9.5 \times 45 + 16.2 p_p + 0.2Y = 772.5 + 0.2Y + 16.2 p_p$

Solution of problem 5.8: cross-price elasticity

1. Express demand as a function of p_p: Substituting value of p

   $Q = 1,200 - 9.5 \times 45 + 16.2p_p + 0.2Y = 772.5 + 0.2Y + 16.2p_p$

2. So $\frac{dQ}{dp_p} = 16.2$

Solution of problem 5.8: cross-price elasticity

1. Express demand as a function of p_p: Substituting value of p

   $Q = 1,200 - 9.5 \times 45 + 16.2 p_p + 0.2Y = 772.5 + 0.2Y + 16.2 p_p$

2. So $\frac{dQ}{dp_p} = 16.2$
3. $\varepsilon = \frac{dQ}{dp} \frac{p}{Q} = 16.2 \times \frac{31}{1{,}275} \approx 0.39.$

Solution of problem 5.8: cross-price elasticity

1. Express demand as a function of p_p: Substituting value of p

   $Q = 1,200 - 9.5 \times 45 + 16.2 p_p + 0.2Y = 772.5 + 0.2Y + 16.2 p_p$

2. So $\frac{dQ}{dp_p} = 16.2$
3. $\varepsilon = \frac{dQ}{dp}\frac{p}{Q} = 16.2 \times \frac{31}{1{,}275} \approx 0.39.$

So a <u>1% increase</u> in the price of palm oil leads to about a <u>0.39% increase</u> in demanded for coconut oil.