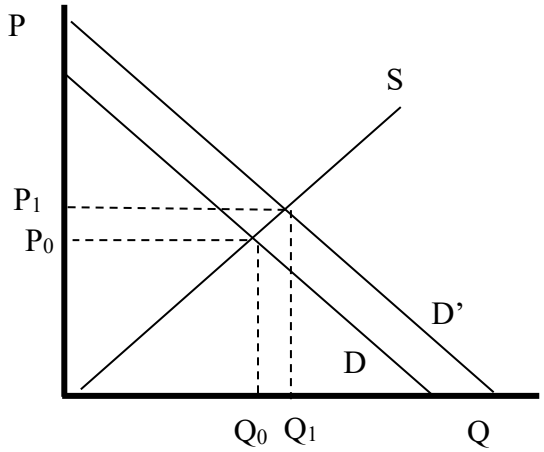
**Practice Problem Solutions PAI897 Professor David Popp Fall 2023**

**1.** The following questions ask you to consider the domestic market for gasoline. Use a supply and demand diagram to analyze each of the following scenarios. Explain briefly. ***Be sure to show how both the equilibrium price and quantity change in each case.***

a) As the economy becomes better, both business and holiday travel increases.
b) Geopolitical instability in major oil producing countries in the Middle East reduces the amount of oil available to import from these countries.
c) In response to increasing minimum fuel economy requirements from the government, the automobile industry has continuously made technological progress improving the average fuel economy of vehicles sold in the U.S. market.

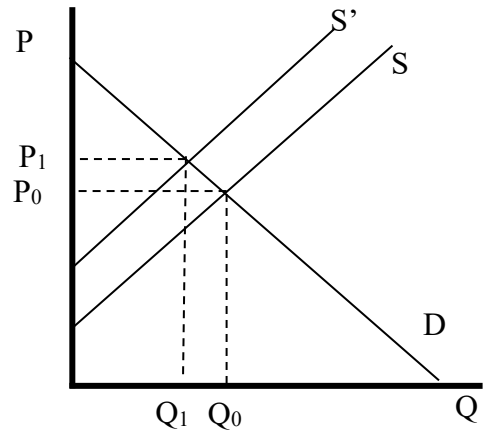
The purpose of this problem is to get you thinking about how demand and supply curves are affected by outside influences, and to help you distinguish between shifts of a curve versus a movement along a curve.

a)

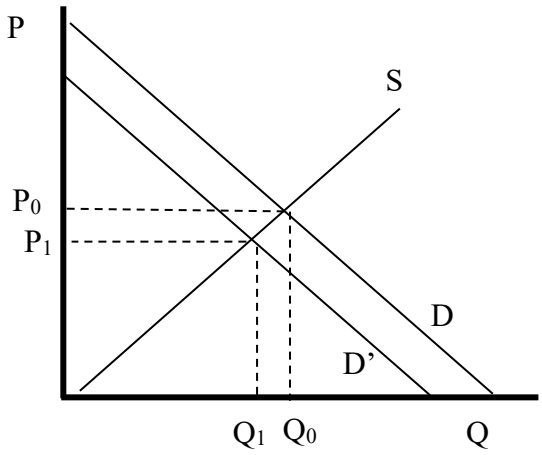



As travel increases, more drivers will need gasoline. As a result, demand shifts up and to the right. The equilibrium quantity and price both increase.

b) The reduction in oil from the Middle East means less oil is available to refine into gasoline. As a result, supply shifts up and to the left. The price of gasoline increases and the equilibrium quantity falls.




c) Improved fuel efficiency means that people now need less gasoline to drive the same distance that they did before. This will reduce the demand for gasoline, causing the demand curve to shift down to the left. Both the equilibrium price and quantity fall.




Note that while the question asks about a technological improvement, it is a technological improvement to a compliment for gasoline – that is, for a product that uses gasoline. Thus, the improvement in fuel efficiency of vehicles does not affect the supply of gasoline, but rather the demand for gasoline.

**2.** Suppose the market for AquaDoodles (once a popular toy) has a supply curve of P = 10 + Q, and a demand curve of P = 150 – 6Q. Assume that the market is perfectly competitive.

a) What will the equilibrium price and quantity of AquaDoodles be?
b) Calculate the producer and consumer surplus associated with the equilibrium found in part (a). Illustrate on a graph.
c) Now, suppose the government levies a tax of $7 per Aquadoodle sold, to be paid by consumers. What is the quantity of Aquadoodles sold? What price do consumers pay? What price do producers receive? Illustrate on a graph.
d) What do the new prices tell you about the price elasticities of supply and demand for Aquadoodles? Which is more elastic? How do you know this?
e) Find the new producer and consumer surplus associated with your answer to part (c).
f) How much revenue does the government raise from the tax?
g) How does the sum of consumer surplus, producer surplus, and revenue after the tax (your answers to (d) and (e)) compare to the sum of producer and consumer surplus found before the tax (your answer to (b))? What does the difference between the two represent?

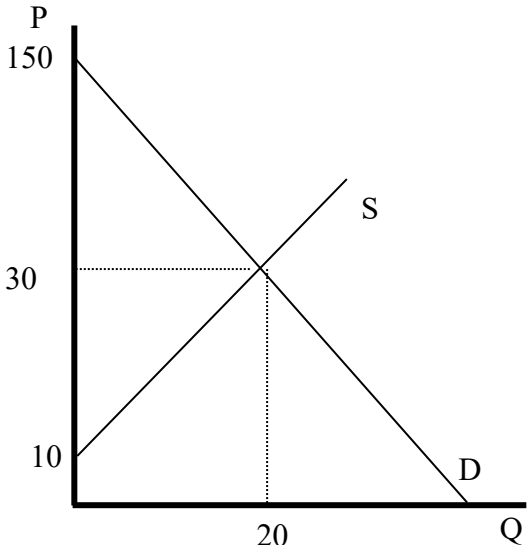
a) The equilibrium price and quantity are:

$$10 + Q = 150 - 6Q$$
$$7Q = 140$$
$$Q = 140/7$$
$$\mathbf{Q = 20}$$

Substitute this into either supply or demand to get:

$$\mathbf{P = 30}$$

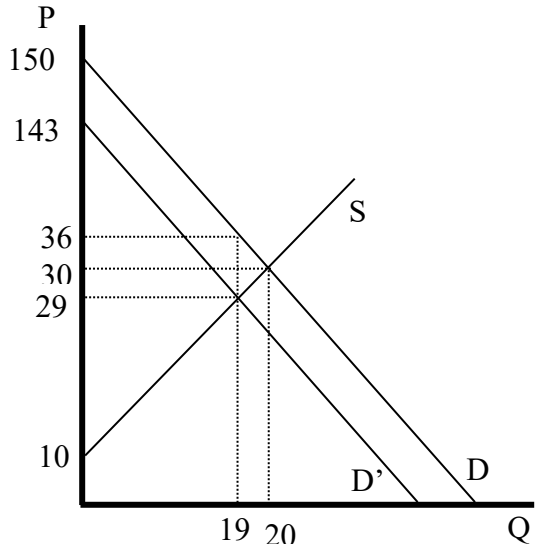
b)




Consumer surplus is the triangle above the price and below demand. It has a height of 120 (= 150 – 30) and a base of 20. Its area = 0.5(120)(20) = **$1200**.

Producer surplus is the triangle below price and above supply. It has a height of 20 (= 30 – 10) and a base of 20. Its area = 0.5(20)(20) = **$200**.

c) The result of the tax is to shift either the supply curve or demand curve in. Note that while your results will be the same no matter which one you choose, the question says that the tax is imposed on consumers, so I shift the demand curve below. The demand curve shifts down by the amount of the tax. The new demand curve represents the demand curve faced by suppliers. If P is the price consumers pay, suppliers get P - 7, with $7 going to the government. Algebraically, P = 150 – 6Q becomes P = 143 – 6Q. Graphically, note that the y-intercept of the graph has shifted down by the amount of the tax.




We begin by finding the new equilibrium. Equate the new supply curve with the old demand curve.

$$10 + Q = 143 - 6Q$$
$$133 = 7Q$$
$$Q = 133/7$$
$$\mathbf{Q = 19}$$

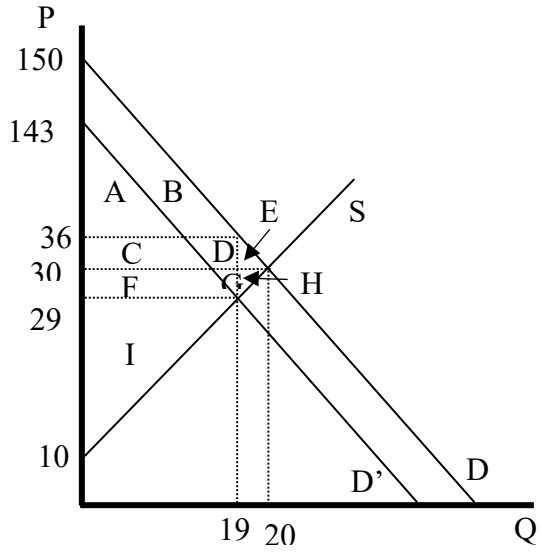
We plug this quantity into the *original* supply and demand curves to get the post-tax prices. With a quantity of 19, suppliers receive:

$P_S = 10 + 19 =$ **$29** (from the original supply curve)

Consumers must pay $7 more than this, or **$36**. Note that we can verify this using the *original* demand curve, where we get $P_C = 150 – 6(19) = 150 – 114 = \$36$.

d) Most of the tax is paid by consumers – their price increases by $6, while producers only receive $1 less. Since inelastic parties bear the larger burden of a tax, this tells us that demand is more inelastic than supply.

e) Note that we use the original supply and demand, at the new prices and quantities, to find consumer and producer surplus.




Areas A & B in the above graph represents consumer surplus. This is a triangle with a height of 114 (= 150-36) and a base of 19. Its area = 0.5(114)(19) = **$1083**.

Area I in the above graph represents producer surplus. This is a triangle with a height of 19 (= 29-10) and a base of 19. Its area = 0.5(19)(19) = **$180.5**.

f) Revenue is simply the tax times the quantity sold.

$7 x 19 = $133.

On the above graph, revenue is the rectangle represented by areas CDFG.

g) Before the tax, the sum of consumer and producer surplus was $1400. Afterwards, the sum of consumer surplus, producer surplus, and revenue is $1396.5. The difference is $3.5. Graphically, this is the area of triangles E & H.

This difference is the deadweight loss. It is the value of lost opportunities, because some potentially beneficial transactions do not occur after the tax. For the quantities between 19 and 20, demand is above supply. This tells us that consumers are willing to pay more than the marginal cost of producing the good. However, because of the tax, these units are not sold. The potential producer or consumer lost because of this is the deadweight loss.

**3.** To encourage increased growth of grasslands in the Animal Kingdom, their leader, Simba, is considering a subsidy for production of grasslands. Suppose that the market for grasslands can be represented by the following equations:

Demand: $P = 200 – 1.5Q$
Supply: $P = 50 + Q$

where P is the price per acre, and Q represents quantity of grasslands, represented in acres consumed per week.

a) Calculate the equilibrium price and quantity of grasslands before the subsidy.
b) To encourage grassland production, Simba announces a price floor of $140 per acre. With this new price floor, what will be the new quantity of grassland consumed in the Animal Kingdom?
c) Illustrate your answers to (a) and (b) on a graph. Using this graph, calculate the consumer surplus and producer surplus at the initial equilibrium price and quantity from part (a).
d) Calculate the new consumer surplus and producer surplus with the price floor of $140 per acre (part b).
e) How does the total consumer and producer surplus in part (c) compare to the total consumer and producer surplus in part (d)? What explains the difference in these two figures?
f) Suppose that the government supports the $140 per acre price by purchasing any excess grassland that producers make available but are unable to sell to other animals. How many acres of grassland must the government buy?

a) The equilibrium occurs where supply equals demand:

$$200 – 1.5Q = 50 + Q$$
$$150 = 2.5Q$$
$$Q = 150/2.5$$
$$\mathbf{Q = 60 \text{ acres}}$$

To find the price, we substitute the equilibrium quantity into either the demand or supply equation:

Either:

$$P = 200 – 1.5(60) = \mathbf{\$110}$$

Or:

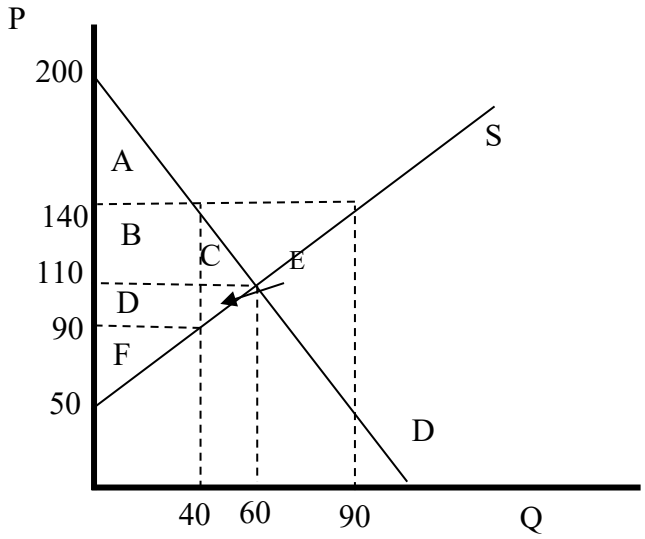
$$P = 50 +(60) = \mathbf{\$110}$$

b) The minimum price is above the equilibrium price. Thus, there will be an excess supply of grasslands – more animals will want to sell grasslands than will be willing to buy grasslands. The new quantity sold will be limited by the number of animals willing to purchase grasslands at this higher price. We find this by substituting \$140 for P in the demand equation, and then solving for Q:

$$140 = 200 - 1.5Q$$
$$60 = 1.5Q$$
$$Q = 60/1.5$$
$$\mathbf{Q = 40 \text{ acres}}$$

c) To draw the graph, we begin by drawing the supply and demand curves. Note that the equations are already solved for P. Thus, we know that the y-intercept (on the price axis) for demand is \$200. Similarly, by setting P = 0, we find that Q = 133.33 when P = 0 (because 200 – 1.5(133.33) = 0).

For supply, we know that the y-intercept is 50, and intersects demand at a quantity of 60 and a price of \$110.




With a price floor of \$140, note that there will be excess supply, so the quantity demanded at \$140 determines the quantity sold. As we found in part (b), this is 40 acres of grasslands.

Consumer surplus is everything above the price and below the demand curve. Before the price floor, this is areas **A, B and C** above. This is a triangle with a height of 90 (= 200-110) and a base of 60. Its area = 0.5(90)(60) = **\$2700**.

Producer surplus is everything below the price and above the supply curve. Without the price floor, this is areas **D, E, and F**. This is a triangle with a height of 60 (= 110-50) and a base of 60. Its area = 0.5(60)(60) = **\$1800**.

d) With the price floor, consumer surplus is everything below demand and above the price of $140. This is area **A** above. This is a triangle with a height of 60 (=200-140) and a base of 40. Its area = 0.5(60)(40) = **$1200**.

The new producer surplus is everything below the price of $140 and above supply. This consists of the rectangle **B and D**, as well as the triangle **F**. To find the area of the rectangle, we need to know the value of the bottom line. This is the price that suppliers are willing to make available for 40 acres of grasslands. Plugging 40 into supply gives us 50 + 40 = 90. Thus, this rectangle has a height of 50 (=140-90) and a width of 40. Its area = (50)(40) = $2000. The triangle F has a height of 40 (=90 – 40) and a base of 40. Its area = 0.5(40)(40) = $800. The total producer surplus is the sum of these two areas, or **$2800**.

e) The total consumer and producer surplus in part (c) is $4500. The total surplus in part (d) is $4000. The difference of $500 is the deadweight loss. This is lost surplus because some of the grassland sales that took place before the introduction of price supports no longer occur. Note that it is equal to areas **C and E** on the graph. This is a triangle with a height of 50 (= 140-90) and a base of 20 (= 60-40), for an area = 0.5(50)(20) = $500.

f) With the price support, there will be an excess supply of grassland. One way for the government to support prices is to purchase this extra supply. To find this, we need to know (a) how much suppliers make available at $140 per acre, and (b) how much consumers purchase at this price. We know from part (b) that consumers purchase 40 acres. To find out how much suppliers make available, plug in the price of $140 to the supply equation:

$$140 = 50 + Q$$
$$Q = 90$$

Since suppliers make 90 acres available, and consumers only purchase 40 acres, the government will need to purchase 50 acres of grasslands at a price of $140 per acre.

**4.** Prince Edward Island is considering raising the fare for the ferry connecting the island to the mainland of Canada by 20%. You have been asked to project whether the fare increase will lead to an increase or decrease in revenues. You have been given the following data pertaining to the last time that fares were increased:

| | **before increase** | **after increase** |
|---|---|---|
| riders per day: | 3,000 | 2,650 |
| fare: | $10 | $12.50 |

a) Based on the figures provided, calculate the price elasticity of demand for trips on Prince Edward Island's ferry.
b) Based on your calculation above, would you expect revenues to increase or decrease if the fare rose by another 20 percent? Why?

a) The formula for elasticity is:

$$\varepsilon = \frac{\%\Delta Q}{\%\Delta P}$$

Recall that $\%\Delta Q = \Delta Q/Q$ and $\%\Delta P = \Delta P/P$. Thus, the percentage change in quantity = -350/3000 = -0.11666, and the percentage change in price is 2.5/10 = 0.25. From this, we calculate the elasticity to be -0.467:

$$-0.467 = \frac{-0.11666}{0.25}$$

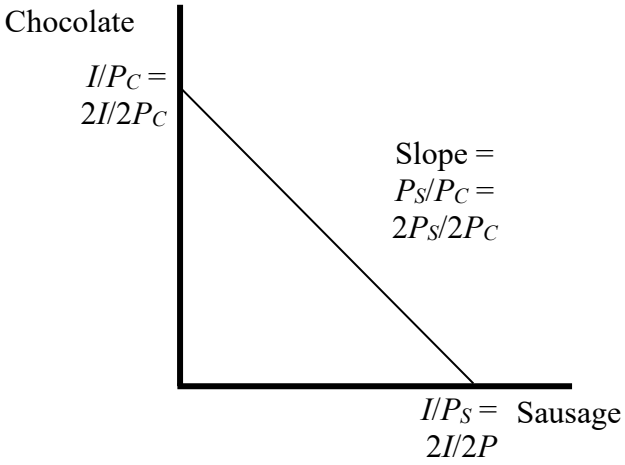
Two common errors here were:

1. Using the new quantity and price, rather than the original quantity and price, to calculate the percentage change, and
2. Using 20% for the change in price. While the proposed price increase is 20%, you must use the previously observed data to calculate the elasticity. The change in quantity that occurred previously was the result of a 25% price increase. Thus, you must use 25%, not 20%, as the change in price.

b) Revenue will increase. Demand is inelastic. Thus, the decrease in quantity demanded will be small relative to the increase in revenues from the higher fare.

Note that simply calculating the new and old revenues only received partial credit. Simply calculating these revenues shows that revenues increase, but does not explain why they increased.

**5.** Reggie consumes only two goods, chocolate and sausage. Suppose that the price of both chocolate and sausage doubles. At the same time, Reggie is given a raise at work, so that his income also doubles. What affect do all of these changes have on Reggie's budget constraint? What does this problem tell you about the effect of inflation that doubles all prices, but in which income also doubles?

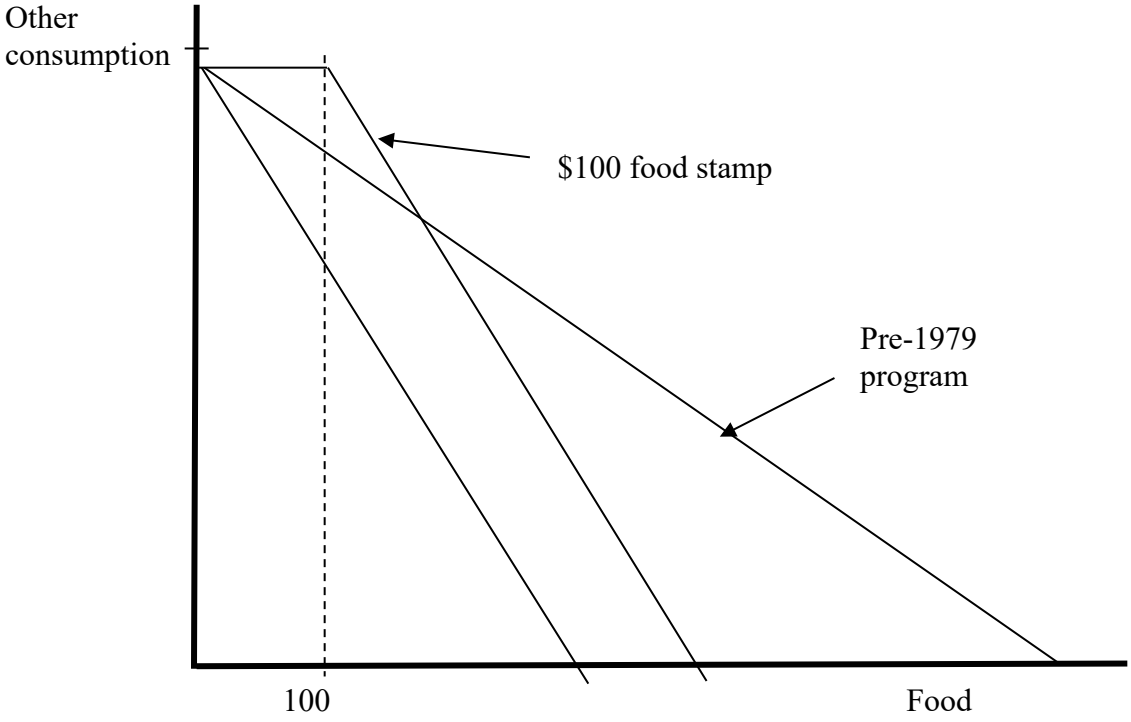



The key to this question is thinking about the interpretation of the x and y intercepts of the budget constraint. In each case, the intercept is the amount of that good that you could consume if you only bought that good. It is found by dividing total income, *I*, by the price of the good, *P*. If both the price and income are doubled, you can still purchase the same amount of the good that you did before. Thus, the budget constraint *does not change* at all. The intercepts are the same because you can purchase the same amount of the good as before, and the slopes have not changed because relative prices ($P_S/P_C$) have not changed. This problem tells us that if prices increase because of inflation, but income rises at the same rate, the inflation has no real effect, since purchasing power remains the same.

**6.** Prior to 1979, the food stamp program required families to pay a certain amount for food stamps. Suppose a family can receive, for example, $150 in food stamps for a payment of $50 (that is, the government pays 2/3 of the cost of food). How would this policy affect the budget line? Compare this plan to an outright gift of $100 in food stamps, which is the way the program works now. Add that budget line to your graph. What would you need to know to determine whether an outright gift of $100 would lead to more, less, or the same food consumption?

The situation prior to 1979 provides a subsidy for food. By spending $50 to purchase food stamps, families can purchase $150 worth of food. Thus, the price of food is one-third the price before food stamps. In this case, the budget constraint simply rotates out. If the family spends all their money on food, they can purchase three times as much food as before

An outright gift of $100 shifts the budget constraint out.



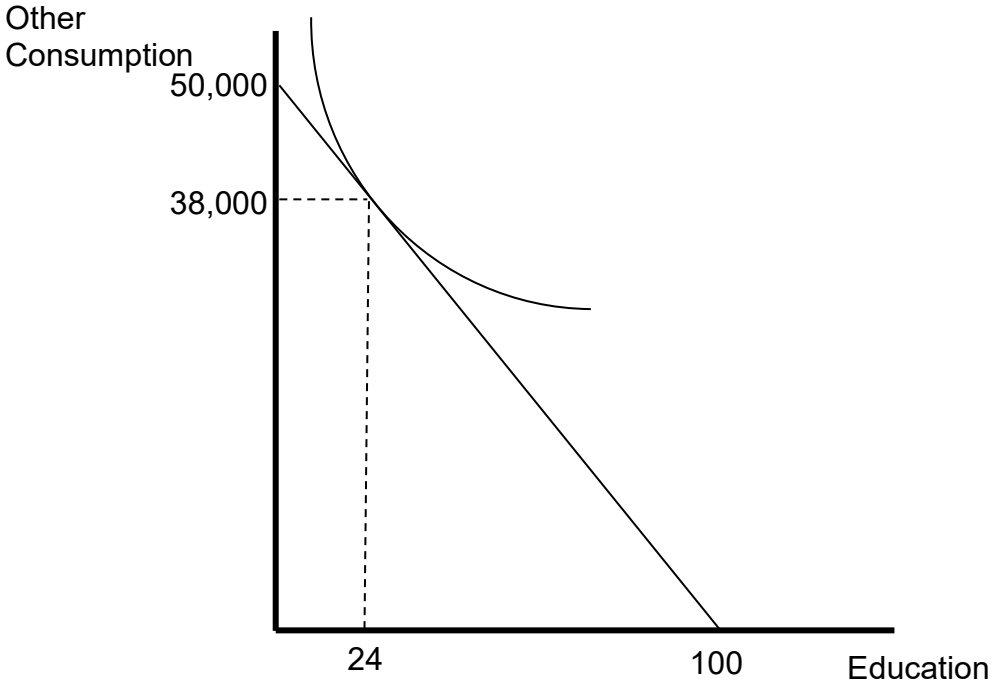

Which plan leads to greater food consumption depends on where the typical family's indifference curve is. Families that desire a lot of food consumption will consume more food with the subsidy. The final indifference curve for these families is to the right of where the budget constraints intersect. Families that prefer more of other goods will get more food with the food stamps, since they cannot consume less than $100 worth of food. These families have indifference curves to the left of the intersection.

**7.** Concerned about increasing tuition rates, Earnest Dummies Unite! (EDU!) proposes an income tax rebate designed to offset increased costs. This question asks you to evaluate their proposal. To begin, consider the following facts for a typical college-aged family:

- Before the increase, tuition rates are $500 per credit hour.
- The typical family with a college-aged student purchases 24 credit hours per year.
- The typical family has $50,000 of disposable income to spend on education or other consumption goods.
-

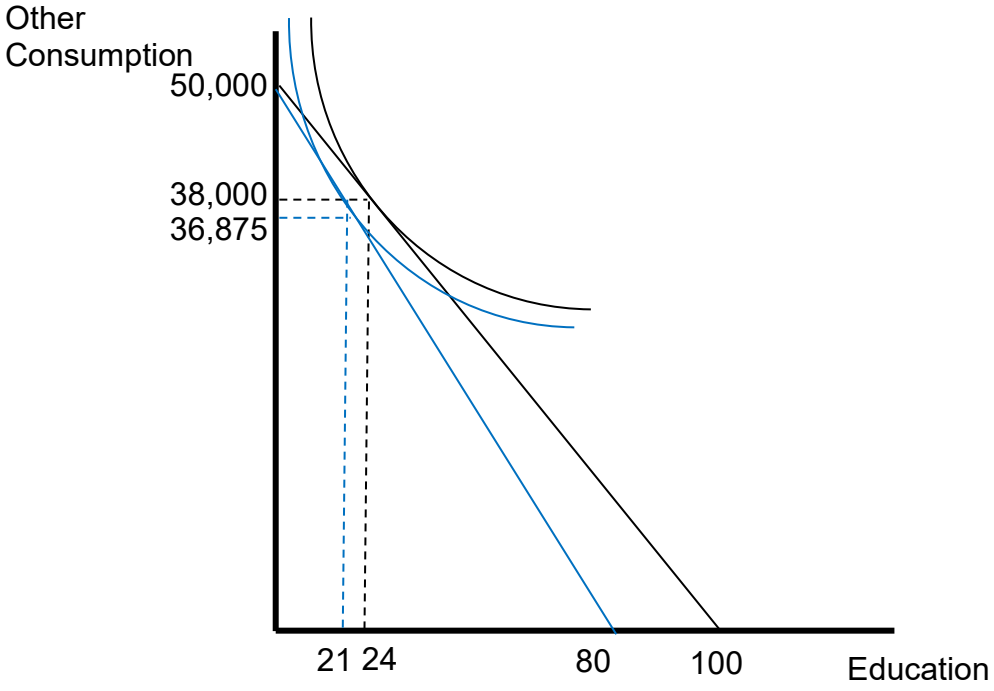
a) Draw a budget constraint and indifference curve for the typical family before rates increase. On the *x*-axis, education should be measured in credit hours purchased. On the *y*-axis, other consumption can be measured in dollars. Be sure to show the endpoints of the budget constraint, as well as the levels of credit hours and other consumption chosen by this family.

To draw the budget constraint, note that consumers can buy up to 100 credit hours of education (= $50,000/$500), or $50,000 worth of other goods. Note that these endpoints are what we need for the budget constraint – we want to show *what is possible*, not just what the consumers actually do. A typical family actually chooses 24 credit hours per year. Since each credit hour costs $500, this leaves them $38,000 to spend on other consumption, as 24 credit hours cost $12,000. This is shown by drawing an indifference curve tangent to the budget constraint at 24 credit hours of education. This is the highest possible indifference curve given the budget constraint.



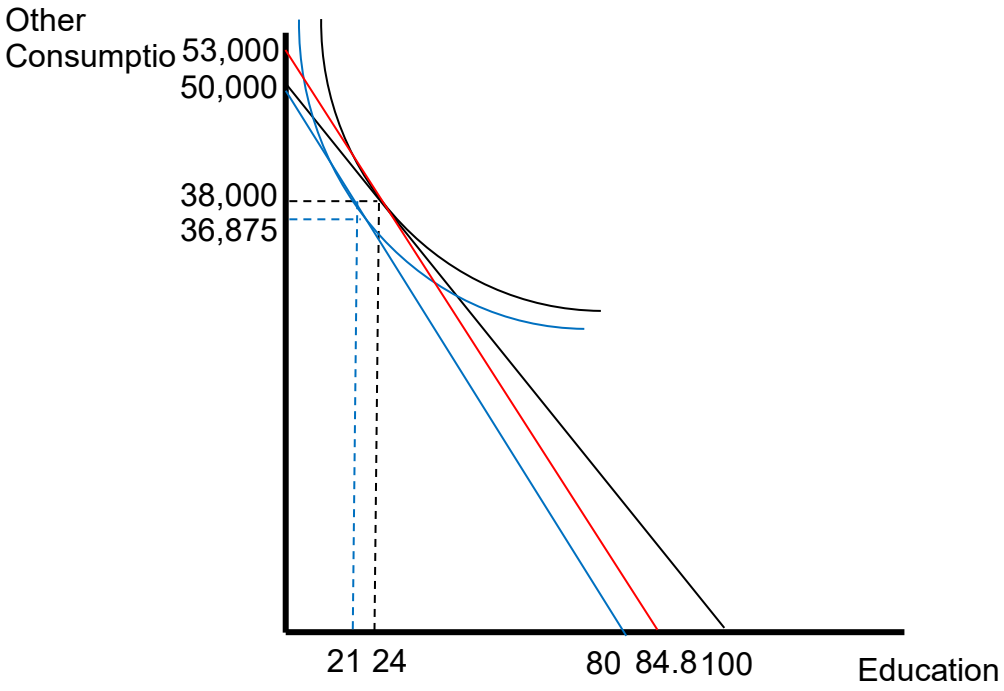
b) Reproduce your diagram from part (a). Now, consider an increase in tuition rates to $625 per credit hour. As a result of the rate increase, the typical family now only consumes 21 credit hours per year. Add the new budget constraint to the diagram, along with a new indifference curve showing the change in consumption patterns.

The price increase rotates the budget constraint in, as shown in blue above. Now, the typical family chooses 21 credit hours, the family will have $36,875 left to purchase other goods (= $50,000 – 21(625)). The new indifference curve, tangent to the new budget constraint, is lower than the original indifference curve. Utility has fallen.



c) Reproduce your answer to (b). Now, consider the proposal from EDU!. They argue that families with college-aged children should receive a $3,000 tax rebate. This will allow them to afford the same combination of credit hours and other consumption that they had before tuition rates rose. Add a budget constraint representing this policy to your diagram.

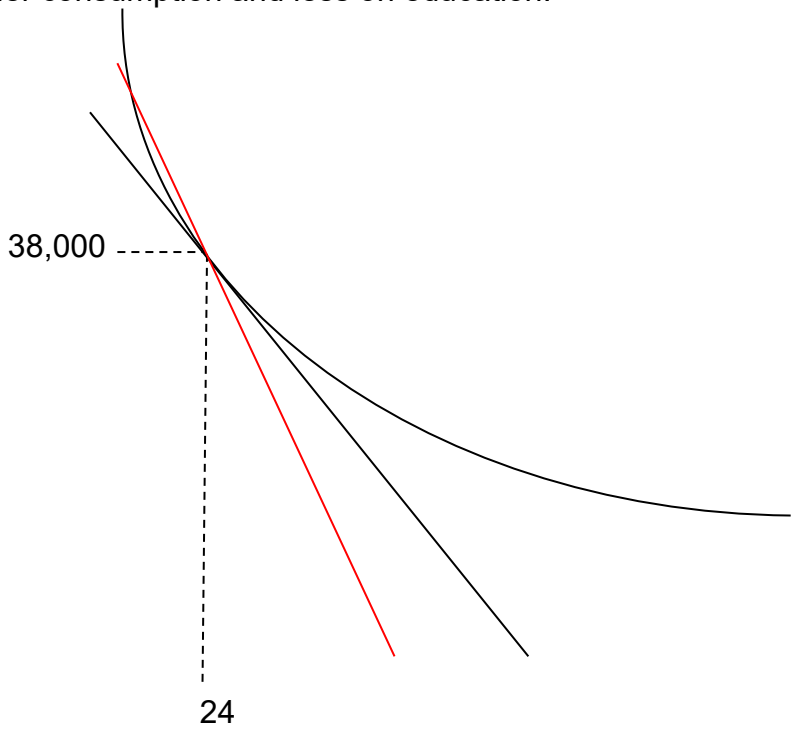
This budget constraint is shown in red below. The budget constraint is parallel to the blue constraint, since the price of tuition remains high, but shifts out by $3,000. Note that it goes through the original consumption point, since it is possible to consume both 24 hours of education and $38,000 of other consumption when total family income is $53,000. However, as we'll discuss further in part (d), the red constraint goes through the original indifference curve.



d) Finally, consider the effects of the proposed tax rebate on welfare. When given the income tax rebate, will families choose to purchase 24 credit hours? How can you tell this? Compared to their utility in part (a) (before the tuition increase), are families worse off, better off, or the same when tuitions are higher and the tax rebate is in place? Explain intuitively why this is the case.

While it is possible for the family to purchase 24 credit hours, they will not. As noted above, the budget constraint goes through the original consumption point. However, given that education remains more expensive, they will substitute away from education. Thus, while they may spend some of the tax rebate on education, they will want to spend more of it on other consumption than they would have had tuition remained at $500 per credit hours.

The intuition above is all that was necessary to answer this question correctly. To see the response graphically, note that the red constraint must cross the original black constraint at the original bundle of 24 credit hours and $38,000 of other consumption. However, since the slope of the red line is steeper than the black budget constraint, it cannot also be tangent to the indifference curve at that point – only one of the budget constraints (the black one in this case) can be tangent, since the slopes must be equal for a tangency to occur. Thus, the red constraint must go through the original indifference curve. This is shown in the close-up of the intersection below. The family could choose a higher indifference curve with more spending on other consumption and less on education.



**8.** You manage one department in a large corporation. Two years ago, you had 20 workers and produced 40,000 units. The company allocated 10 more workers to your department last year, and output increased to 45,000. You just received a memo from your boss indicating that he is very concerned about the 500-unit fall in the average productivity of your workers. How can you defend yourself?

Defend yourself by noting that you were only given additional labor. Because of *diminishing returns to inputs*, the marginal productivity of the additional labor was less than before. Since marginal product was falling, average product must fall.

The problem is likely one of capacity constraints. If you were also given more capital to work with, the productivity of the labor could be maintained.

**9.** You are in charge of cost control in a large metropolitan transit district. A consultant you have hired comes to you with the following report:

Our research has shown that the cost of running a bus for each trip down its line is $30, regardless of the number of passengers riding the bus. Each bus can carry 50 people. At rush hour, when the buses are full, the average cost per passenger is 60 cents. However, during off-peak hours, average ridership falls to 18 people, and average costs soar to $1.67 per passenger. As a result, we should encourage more rush hour business when costs are cheaper, and discourage off-peak business when costs are higher.

Should you follow the consultant's advice? Why or why not?

You should not follow the consultant's advice. The problem with the advice is that he or she is ignoring why the costs vary. Because the cost of running a bus is fixed, the average cost falls as the number of riders increases. Lowering ridership during off-peak hours will *increase* average costs. Similarly, the buses are currently full at rush hour. The only way to increase ridership during rush hour is to run more buses (assuming more buses are available), since the current buses are filled to capacity. Thus, adding more riders at rush hour leads to greater fixed costs.

Rather than lowering ridership during off-peak hours, it would make more sense to encourage more ridership then. For example, charging a lower fare during off-peak hours, and a higher fare during rush hour, would encourage those with flexible schedules to take the bus during off-peak hours.

**10** CSI, Community Services, Inc., uses a combination of high school students and professional staff to provide services to low-income families in the community. High school students are able to serve 4 families per day, whereas professional staff can serve 20 families per day. Students are paid $40 per day, whereas professionals are paid $100 per day. Their accountant argues that CSI could lower costs by using more students and fewer professionals, while still serving the same number of families. Given the data above, do you agree with this assessment? Why or why not?

The accountant's assessment is incorrect. To minimize costs, CSI should consider how much it costs per family served – the marginal product per dollar spent on each type of worker. We are given information on the marginal product for each type of worker, as well as the cost per day for each. Comparing the two, we see:

$$\frac{MP_{Professional}}{w_{Professional}} \; ? \; \frac{MP_{Student}}{w_{Student}}$$

$$\frac{20}{100} \; ? \; \frac{4}{40}$$

$$0.2 > 0.1$$

Thus, we see that, given the current allocation, professionals serve more families per dollar spent than high school students. Thus, CSI could actually lower costs by using *more* professionals and fewer students.

Alternatively, some of you did the inverse:

$$\frac{w_{Professional}}{MP_{Professional}} \; ? \; \frac{w_{Student}}{MP_{Student}}$$

$$\frac{100}{20} \; ? \; \frac{40}{4}$$

$$5 < 10$$

As long as you interpret this result correctly, your answer will be the same. In this case, rather than calculating the number of families served per dollar spent, you are calculating the cost per family served. The cost per family served is lower for professionals, so more professional staff should be used.

**11.** Tom's Terrific Turkeys is getting ready for the Thanksgiving rush. Turkeys sell for $30 each, and the market is perfectly competitive. Tom has prepared the following data for his firm:

| Q | TC | MC | ATC | AVC |
|---|---|---|---|---|
| 0 | $10 | -- | -- | -- |
| 1 | $20 | $10 | $20 | $10 |
| 2 | $35 | $15 | $17.5 | $12.5 |
| 3 | $55 | $20 | $18.33 | $15 |
| 4 | $80 | $25 | $20 | $17.5 |
| 5 | $110 | $30 | $22 | $20 |
| 6 | $145 | $35 | $24.17 | $22.5 |

a) What are the fixed costs for Tom's firm? How do you know this?

Tom's fixed costs are $10. We know this because he has to pay $10 even if he does not produce any turkeys.

b) Given the current market price of $30, at what quantity would Tom maximize profits? Explain the economic intuition behind your answer.

Since the turkey market is perfect competition, Tom is a price taker, and can sell as many turkeys as he can at $30. Thus, Tom's marginal revenue is $30. To maximize profit, Tom should equate marginal revenue to marginal cost. This occurs when Tom sells 5 turkeys. At this quantity, the amount of extra money he makes by selling a turkey is the same as the additional cost of producing another turkey.

c) Is a price of $30 a long-run equilibrium for the turkey industry? Why or why not?

No. Tom makes a profit of $40 when he sells 5 turkeys at $30 each. (Total revenue = 5 x $30 = $150, and total cost = $110). In long-run equilibrium, firms must make 0 profits. Because there are profits available, firms will enter the turkey industry until the price falls enough so that no more profits are available.

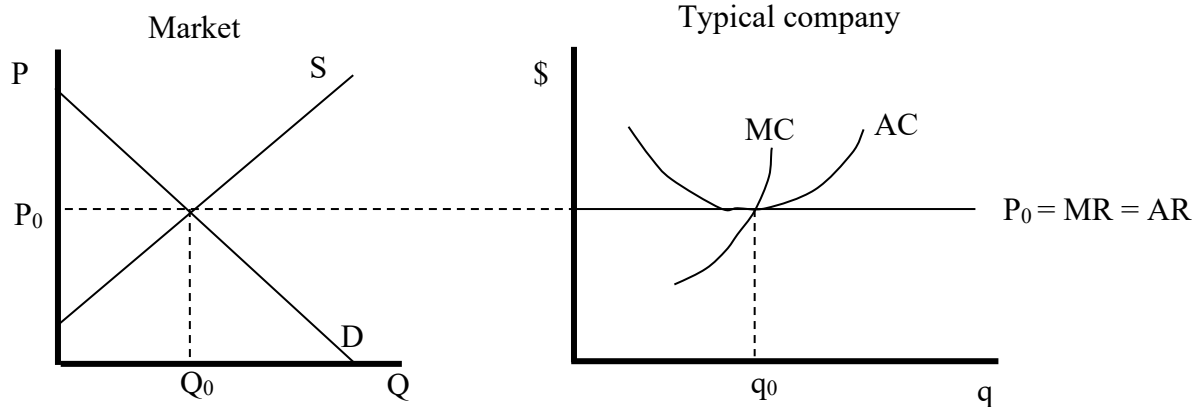
d) Suppose the price fell to $15? How many turkeys would Tom sell now? Would he make a profit? Should Tom continue to operate in the short run? Why or why not?

Tom would sell 2 turkeys. He would lose $5. He should continue to operate, however, since he is at least covering his variable costs, and has some money left to pay some of his fixed costs. If he decided to shut down, he would lose $10 (his fixed costs). Obviously, this is worse than losing $5.

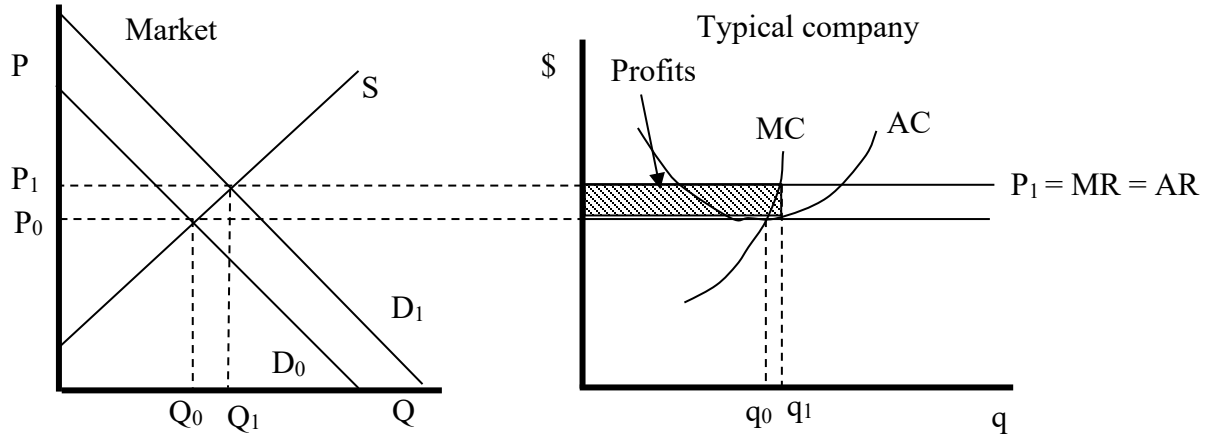
**12.** This question asks you to consider the market for cab rides in Metropolis. The city is currently served by several cab companies, each who own multiple cabs and hire drivers to operate them. The number of cab companies is sufficiently high to consider the market perfectly competitive.

a) The industry is currently in long-run equilibrium. Using two diagrams, one to represent the market for cab rides, and a second to represent the costs of a typical cab company, illustrate the current price, quantity and profits of a typical cab company. Explain why you have drawn the curves as you did.
b) To reduce traffic in Metropolis, city managers have reduced the number of parking spaces in the city. This has reduced the number of people who bring their own cars into the city, and increased demand for cab rides. Show how this affects the market equilibrium, price, and profits immediately after the policy takes affect. Using one diagram for the cab ride market and a second for a typical cab company, illustrate below.
c) Will the scenario you have described in part (b) be a stable long-run equilibrium? Why or why not? Once again using separate diagrams for both the industry and a typical cab company, illustrate the long run equilibrium for cab rides in Metropolis.
d) To avoid the possibility you discuss in (c), cab companies lobby for licensing rules that prohibit new entry. They argue that, to avoid new congestion problems, only drivers approved by the city should be allowed to operate cabs. Moreover, they argue that the number of approved drivers should equal to the number of drivers operating before the number of parking spaces was reduced. How would that change your answer to part (c)? Why?
e) Economists often call such lobbying efforts "rent seeking" behavior. Why do you think this is? What is the most that the industry would be willing to spend on such lobbying?

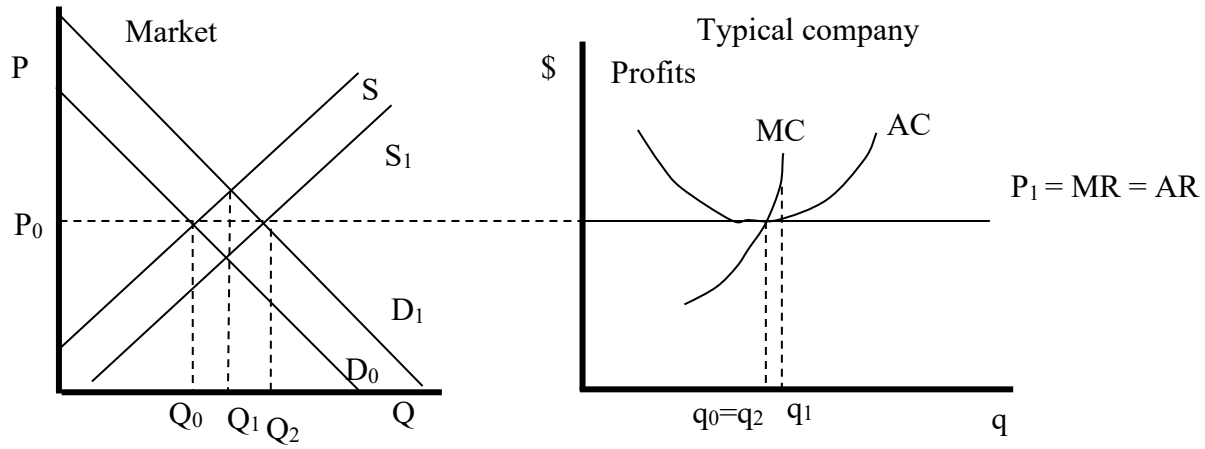
a) In long-run equilibrium, firms are making zero economic profits. The price must be equal to the marginal cost at the point where MC intersects the AC curve.



b) The new policy increases demand for cab rides, so demand shifts to the right. In the short run, increased demand leads to a higher equilibrium price and quantity. Each cab company provides more rides than it did before, and earns positive economic profits.




c) No, it will not be a stable long-run equilibrium. Since cab companies are making positive economic profits, more companies will enter the market, shifting supply out. As a result, the price of cab rides will fall. This will occur until the price returns to its original level, with cab companies making zero economic profit.



d) By restricting the number of drivers, supply would not be able to shift out. The result of part (b) would remain in place, and current cab companies would earn positive economic profits.

e) The positive profits earned in part (d) are an example of economic rent. Intuitively, the extra value from the restriction is now capitalized into the "price" of a cab company. If the owner of a cab company making long-run economic profits decided to sell the company, she would be able to sell for a higher price than for a cab company making zero economic profits.

   Since the policies that result from this lobbying result in economic rent, economists often refer to such behavior as "rent seeking." The most an industry would be willing to spend on rent seeking is the total value of the profits to the industry.

**13.** Evaluate the following statement:

**"**The First Theorem of Welfare Economics states that as long as producers and consumers act as perfect competitors, and there are no other market failures, a Pareto efficient allocation of resources emerges. Thus, if market failure is not evident, there is no justification for government intervention in the economy."

This statement assumes that the only justification for government intervention is market failure. However, the First Theorem of Welfare Economics only states that, in the absence of market failure, an efficient solution results. It does not say anything about the desirability of efficiency. Recall from class that an efficient solution could nonetheless involve a very inequitable distribution of income. Some people may find this objectionable, and argue that government intervention is needed to promote more equality.

**14.** For each of the policy proposals below, identify who the potential beneficiaries and losers (if any) are. Then, state whether the change is likely to be:

1) a Pareto improvement
2) an improvement in social welfare using a Rawlsian social welfare criterion.

Explain briefly.

a) Providing free health care to low-income families, financed by increasing income taxes

The potential beneficiaries are those receiving free health services. These will all be low income families.

The losers are those who are pay higher income taxes but do not receive additional health services. Since low-income families pay little or no income tax, most taxpayers will be losers in this scenario.

Because one group benefits at the expense of another, this policy is not a Pareto improvement.

However, because it benefits the least well-off members of society, it is an improvement in social welfare using a Rawlsian social welfare criterion.

b) Providing free public wi-fi, financed by an increase in sales taxes

The potential beneficiaries are those who would use the free public wi-fi. Presumably, one will need to use a cell phone or laptop to access these services.

Losers in this scenario are those who pay higher sales taxes but receive little or no benefit from free public wi-fi. For instance, those who don't use a cell phone would not benefit.

Since not everyone owns a cell phone, there will be some consumers who pay more in sales taxes but do not enjoy the benefits of free public wi-fi. Thus, the policy is not a Pareto improvement.

To be an improvement in welfare under a Rawlsian social welfare criterion, the policy must improve the welfare of the least well-off people in the community. Since the poorest people in the community are unlikely to own a cellphone, this policy is likely not a welfare improvement under a Rawlsian social welfare function.

c) Providing free public wi-fi, financed by a tax on cell phone users.

The potential beneficiaries are those who would use the free public wi-fi. Presumably, one will need to use a cell phone or laptop to access these services. Thus, the beneficiaries are also the ones paying the cost of free public wi-fi. Thus, there are not clearly identified losers in this scenario. (A possibility is someone who only uses their phone to make phone calls, and thus doesn't care about free public wi-fi.)

While it is not necessarily the case, it is possible that this policy could be a Pareto improvement. If cell phone users value free public wi-fi service at least as much as the cost of the tax increase, it is a Pareto improvement.

However, the policy is not an improvement in welfare under a Rawlsian social welfare criterion, since it does nothing to improve the welfare of those who are so poor that they do not use a cell phone.

In answering these questions, note that a Rawlsian social welfare criterion does not necessarily imply competition among different classes – it is just that if focuses on the well-being of those who are the worst off. For example, some students said that the tax on cell phone users is an improvement with a Rawslain social welfare criterion, because it makes laptop users better off at the expense of cell phone users. That is incorrect. The key question is whether the policy makes the *worst off* people in society better off.

**15.** Doug's Dogs has the exclusive rights to hot dog vending at SU football games. Assume that the marginal cost of producing hot dogs is constant at $1. Daily demand for hot dogs is P=5-(Q/20). Assume that fixed costs equal zero.

a) Find Doug's profit-maximizing quantity of hot dogs and the price at which hot dogs are sold.
b) What are Doug's profits? What is the consumer surplus?
c) Suppose competition is allowed among hot dog vendors at the games. What will the new price and quantity be? Explain how this problem differs from the monopoly problem above.
d) Find the new consumer surplus and profits. How does the sum of consumer surplus and profits in the monopoly case (part b) compare to consumer surplus with perfect competition? Explain any differences between the two.

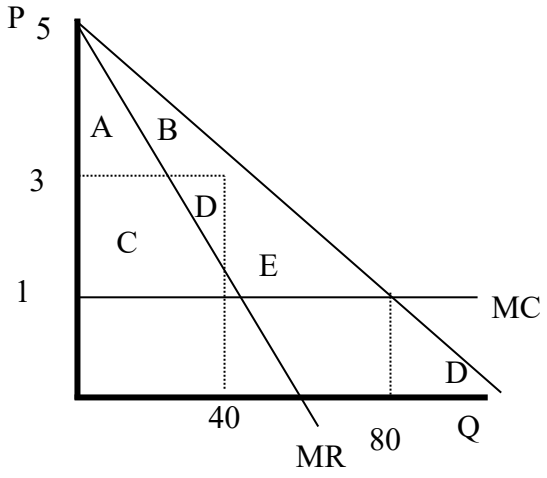
a) Profits are maximized where MR=MC. Since Doug is a monopolist, we know that his marginal revenue curve bisects the demand curve faced by Doug. Thus, MR = 5 - (Q/10).

$$MR = 5 - (Q/10) = 1 = MC$$
$$Q/10 = 4$$
$$\mathbf{Q = 40}$$

To get the price, we need to look at the demand curve, to see how much consumers are willing to pay for 40 hot dogs. We get:

$$P = 5 - (40/20)$$

b) Doug's profits are total revenue minus total cost. Total revenue = PxQ = $120. Because marginal costs are constant and there are no fixed costs, we can get total costs by multiplying MCxQ. Thus, total costs are $40. His profits are **$80**.




**P = 3**

On the graph to the right, consumer surplus is equal to areas A and B. This area is a triangle with base 40, and a height of 2 (=5-3). Thus, consumer surplus = 0.5(40)(2) = **$40**.

c) If competition is allowed, each vendor will now be a price taker, so that MR= P. In equilibrium, MR is equated with MC, which is 1. Thus, the new equilibrium price is **P = 1**.

To get Q, we plug into the demand equation to get:

$$1 = 5 - (Q/20)$$
$$Q/20 = 4$$
$$\mathbf{Q=80}.$$

d) Now, the consumer surplus is areas ABCDE. This is a triangle of base 80, and height 4. Its area is 0.5(80)(4) = 160. Thus, consumer surplus = **$160**.

To calculate profits, note that total revenue = PQ = 80, and total cost = MCxQ = 80. Thus, there are no profits.

The sum of consumer surplus and profits is $40 greater than the sum from before. The difference was the deadweight loss from the monopoly (area E).

**16.** *Using theories discussed in this class*, what rationale can you provide (if any) for government intervention in the following areas? Your answer should both clearly state whether or not you think the proposed service makes sense, and should use economic logic to defend your answer.

a) Prohibiting smoking in public buildings

Because of the dangers of second-hand smoke, smoking creates negative externalities to those nearby. Thus, prohibiting smoking in public buildings can be justified by reducing the harm from second-hand smoke, and thus reducing a negative externality.

b) Food stamps

Providing food stamps cannot be justified as correcting a market failure. Rather, support for food stamps depends on concerns about equity and redistribution. For example, if market forces leave some families with insufficient food for sustenance, we may support food stamp programs as a way to provide a minimum level of food consumption for everyone.

c) Public transportation

There are several possible justifications that could be offered for public transportation. First, public transportation reduces traffic congestion and the pollution that comes from traffic. Thus, the use of public transportation helps reduce negative externalities. One could also support public transportation for equity reasons. For example, public transportation can be used by low-income citizens that cannot afford their own vehicle. Government provision of a natural monopoly is another possible answer. It would not be sensible to duplicate the infrastructure (particularly for things such as subway tunnels) to allow multiple companies to compete on public transit routes. Thus, a single operator makes sense. Having the government as this operator prevents a for-profit firm from abusing monopoly power over public transport.

One justification that does not work here is public transportation as a public good. Public transportation has neither of the features of a public good. It is excludable – you cannot use the service without paying. Moreover, as anyone who has rode public transportation in a large city at rush hour can attest, it is also rival.

**17.** Canterbury and Midland are remote regions in the country of Amazonia separated by a large mountain range. To travel from one region to the other, drivers must either take a series of narrow, windy roads over the mountains or drive around the mountain range. Either route takes 3 hours to complete.

The leader of Amazonia proposes building a tunnel through the mountains. This tunnel will provide a direct route connecting Canterbury and Midland, and reduce the travel time between these regions to just 45 minutes. Because the tunnel will reduce travel times, reduce congestion on narrow mountain roads, and stimulate economic development in these regions, he argues that the tunnel is a public good.

Do you agree? Using theories discussed in class, should the tunnel be considered a public good?

A public good has two features: it is *non-rival*, meaning that many people can use the good at the same time, and it is *non-excludable*, meaning that we cannot prevent people from using the good, making it difficult to collect a fee for usage. Neither applies here. Thus, while the tunnel may be beneficial to Amazonia, the tunnel is not a public good.

As the tunnel becomes more crowded, travel times will fall. Thus, congestion is a possibility. While it may be non-rival for low levels of traffic, at some point it will become rival. A few people pointed out that, since congestion is only a problem for high traffic levels, the tunnel has characteristics of a club good.

Similarly, although Amazonia may choose to not charge a toll for using the tunnel, the decision to finance the tunnel by other means is a choice. It is not a feature of the tunnel. Since there are limited entry points, it would be possible to charge a toll to drivers using the tunnel. Thus, excluding people who don’t pay would be feasible.

**18.** Suppose three neighbors must vote on installation of a traffic light that costs $210. All three will share the cost of the light – that is, each person will contribute $70 to the installation. Leona values the light at $50; Lionel values the light at $50; and Theo, who drives the most, values the light at $200.

a) Explain why the traffic light is a public good.
b) Is it efficient for the traffic light to be installed? Why or why not?
c) Suppose a majority rule vote is held to determine whether the light should be installed. Will the light be installed? Explain any differences between this result and your answer in part (b).

a) The traffic light is both non-rival and non-excludable. It is impossible to keep anyone from enjoying the benefits (increased safety at the intersection) of the traffic light. In fact, I suspect that we would be upset if anyone tried to ignore the benefits! In addition, it is non-rival. More people using the light will not reduce its benefits.

b) It is efficient for the traffic light to be installed. Since this is a public good, we need to compare the social marginal benefit – that is, the sum of individual marginal benefits – to the marginal cost. The sum of marginal benefits equals $300. Since the traffic light only costs $210, it should be installed.

c) If the traffic light is approved, each voter must pay $70. To determine whether an individual will vote yes or no, compare the voter's individual benefit to their share of the cost:

Leona = 50 – 70 = -$20
Lionel = 50 – 70 = -$20
Theo = 200 –70 = $130

Since two of the three voters have negative net benefits, the traffic light will not pass. Both Leona and Lionel will vote against the light. The problem here is that the yes/no referendum does not reflect the intensity of an individual's preferences. The two who vote against the light have only a small negative net benefit. Theo, the main beneficiary of the light, gains significant benefits from its installation. However, his yes has only as much weight as one of the two no votes.

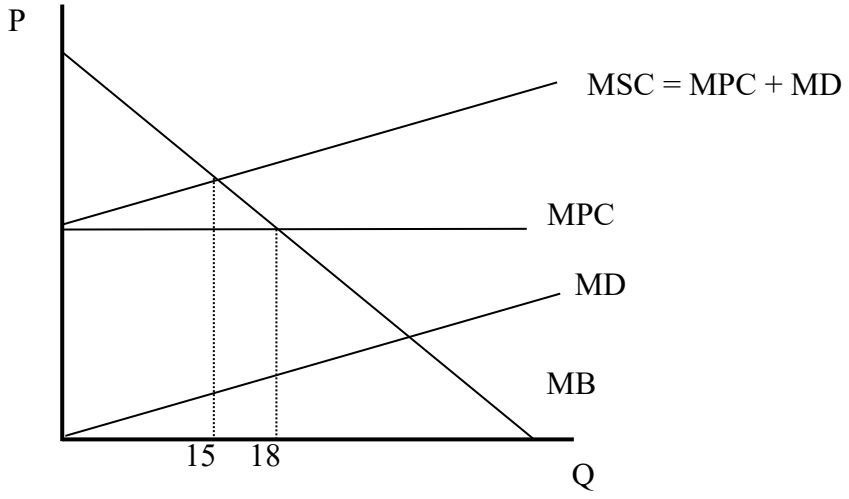
**19.** Mack's Messy Marbles manufactures marbles. The marginal cost per bag of marbles is $4. The marbles are carefully hand-painted by local artisans. Unfortunately, while painting such small surfaces, much paint is spilled and drains into the local river. Many families live along the river, and they all own boats. Thousands of boats that are docked along the river are harmed by this paint. The damage done by the paint can be represented by the equation MD = 0.2Q. The demand curve for marbles is P = 22 - Q.

a) From a societal viewpoint, what is the efficient level of marble production?
b) How many marbles are produced without government intervention?
c) What can be done to ensure that an efficient number of marbles are produced?

a) To find the efficient level of production, we equate the social marginal cost and demand. Social marginal cost is the sum of private marginal costs (4) and marginal damages (0.2Q). (Note that the marginal cost of production is constant at 4, since *each additional bag of marbles* costs $4. It is not correct to use 4Q for marginal cost. 4Q is the *total cost* -- the cost of each unit times total output. To find the optimal point, we must work with marginal values.)

We get:

$$SMC = 4 + 0.2Q = 22 - Q = \text{demand}$$
$$1.2Q = 18$$
$$\mathbf{Q = 15}$$

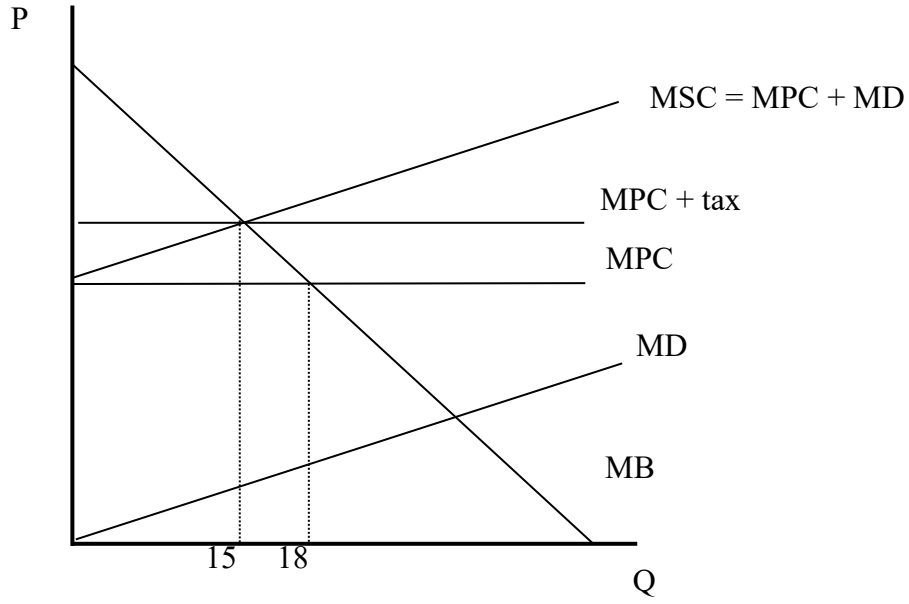



b) Without government intervention, Mack's will equate demand and private marginal costs. Overproduction results:

$$4 = 22 - Q$$
$$\mathbf{Q = 18}$$

c) To encourage an efficient level of production, we need to make the firm take the social costs of its production into account. A Pigouvian tax will do this. We set the tax equal to the marginal damage *at the optimal point*. This is equal to **$3** (0.2x15). The firm must pay a $3 tax for each unit produced. With a Pigouvian tax, the firm's MC = 7. Thus,

$$7 = 22 - Q$$
$$\mathbf{Q = 15}$$



**20.** Negotiators are currently working to craft a new international agreement to limit emissions of greenhouse gases that contribute to climate change. Consider two hypothetical countries, Freedonia and Drusselstein. Below are estimates of the marginal costs of abatement of greenhouse gases for each country:

| Abatement (in tons) | Freedonia | Drusselstein |
|---|---|---|
| 1 | $15 | $25 |
| 2 | $20 | $35 |
| 3 | $25 | $45 |
| 4 | $30 | $55 |
| 5 | $35 | $65 |
| 6 | $40 | $75 |
| 7 | $45 | $85 |
| 8 | $50 | $95 |
| 9 | $55 | $105 |
| 10 | $60 | $115 |

a) The negotiator's goal is to reduce 10 tons of greenhouse gas emissions. To do this, they first consider requiring each country to abate 5 tons. What is the total cost of abatement for Freedonia? For Drusselstein? What is the combined total for both countries?

b) Is this the cheapest way to reduce 10 tons of emissions? If not, can you suggest a better strategy? How many tons should Freedonia reduce to minimize clean-up costs? How many tons should Drusselstein reduce to minimize clean-up costs? Please explain how you found your answer.

c) For firms within a single country, what types of policies are used to achieve an allocation of clean-up responsibility such as you suggested in part (b)? Explain how such policies work to bring about the efficient solution. What hurdles might the implementation of such a policy face in an international setting, when allocating emission reduction responsibilities across countries, rather than across firms within a single country?

a) To find the total costs of abatement for each country, we add up the marginal abatement costs for each ton:

For Freedonia, the total cost of abatement = $15 + $20 + $25 + $30 + $35 = **$125**.
For Drusselstein, the total cost of abatement = $25 + $35 + $45 + $55 + $65 = **$225**.

Thus, the combined total costs of abatement are **$350**.

b) This is not the cheapest way to reduce 10 tons of emissions. To see this, note that marginal abatement costs of the last gallon reduced are not equal. Eliminating the 5th ton of emissions only costs Freedonia $35. In contrast, eliminating the 5th ton costs Drusselstein $65. If Drusselstein did not have to eliminate this 5th ton, they would save $65. At the same time, suppose we ask Freedonia to remove one additional ton (so that total abatement remains at 10 tons of emissions). This would only cost Freedonia $40. Thus, we could still reduce 10 tons of emissions, but save $25 (= 65-40).

Such savings are possible any time the two marginal abatement costs aren't equal. Thus, we can continue making such trades until the marginal abatement costs are equal. This occurs when Freedonia removes **7** tons of emissions and Drusselstein removes **3** tons of emissions. Here, the marginal abatement cost of each country equals $45.

Note that the total abatement costs have now fallen. Freedonia's cleanup costs rise slightly, to $210. However, Drusselstein now spends only $105 on pollution abatement. The total abatement cost of $315 is $35 lower than in part (a).

c) For firms within a single country, there are a couple of policy options that are commonly used to achieve an efficient allocation of abatement responsibility. One is an *emissions fee*. Consider an emissions fee set just above $45 (e.g. $45.01). For Freedonia, they will not choose to pollute and pay the fee until they have removed 7 tons of emissions, since the marginal abatement cost for the first 7 tons is less than the fee. In contrast, Drusselstein will only remove 3 tons of emissions. After that, it is cheaper to pay the fee than to pollute less.

An alternative policy with the same effect would be to give each firm tradable pollution permits. We could begin by giving each firm enough permits to cover one-half of their pollution. Thus, the starting point is similar to the current policy. However, if firms are allowed to buy and sell permits, Drusselstein will buy permits from Freedonia until their two marginal abatement costs are equal. At that point, no more beneficial trades are possible. For example, beginning with the initial allocation, Freedonia and Drusselstein could negotiate a permit price anywhere between $40 and $50. At this price, Freedonia could sell one permit to Drusselstein. Since Freedonia's marginal abatement cost for the 6th ton is $41, any price above $40 allows them to cover the clean-up costs and save the remainder as profit. Similarly, by reducing one less ton of pollution, Drusselstein saves $65. Thus, they are willing to pay any price up to $65 to avoid the clean-up cost.

However, since these are countries, rather than firms, implementing such policies would be difficult. No international agency has the authority to tax countries or to punish them if they do not have a sufficient number of permits. International agreements can be reached to set up such enforcement systems. The World Trade Organization is an example. However, even these agreements can have flaws. For instance, consider how the US announced in 2017 that it will pull out of the Paris Agreement. No mechanism in the agreement exists to punish the US for withdrawing.

**21.** Characterize each of the following as an example of (i) adverse selection, (ii) moral hazard, or (iii) principal-agent problem. Explain briefly.

a) A savings and loan association, with federally insured funds, makes risky investments.
b) A physician prescribes tests that are relatively expensive and ineffective for treating a patient's illness.
c) An employee signs up for disability insurance, aware of having an illness that is likely to be disabling.

a) This is an example of moral hazard. Because the bank is insured, it can take greater risks, because it will not pay the full cost of a negative outcome.

b) This is an example of a principal-agent problem. The doctor is compensated for the tests provided, whether or not the patient gets better. Prescribing more tests rewards the doctor, but does not help the patient.

c) This is an example of adverse selection. Those most likely to benefit from insurance are more likely to purchase it.

**22.** Concerned about trash in neighborhood parks, the city of Urbana has decided to undertake a beautification project. As a result of cleaner, more attractive parks, they expect that park attendance will increase by 10%. They also project that property values of homes near the park will increase by $5,000 per home. There are 1,000 homes that are considered "near" local parks.

a) What are the benefits of the beautification project?
b) How would you measure these benefits?

a) The benefits of the beautification project are the increased recreation opportunities due to a cleaner, more attractive park. The city estimates that these opportunities will increase by 10%, and that residents of 1,000 homes will take advantage of these opportunities.

b) We can use the increase in property values to place a dollar value on the increased recreation opportunities. Homes near the park will be worth $5,000 more after the beautification project. That is, people are willing to pay an extra $5,000 to be in a location where they can enjoy the cleaner park. 1,000 homes are near the parks. Thus, the total value is $5,000,000 (=$5,000 x 1000).

Note that, in doing a cost-benefit analysis, you could simply list the benefits as the 10% increase in recreational opportunities, or you could value these benefits at $5,000,000. However, including a $5,000,000 benefit plus 10% additional recreational opportunities would be double counting, as it is increased opportunities from cleaner parks that cause the property values to rise.

**23.** We Like Sports (WLS) is a group of citizens lobbying for a new sports stadium for the local baseball team. They argue that the new stadium would have several benefits:

- Currently, the team attracts 1 million spectators a year. WLS projects that with the new stadium, 1.5 million fans will attend games. Each fan spends $30 at the game, which generates $3 in taxes. This will create additional revenue for the city.
- In addition to spending money on the games, WLS argues that these fans will bring more revenue to the city. They project that one-half of these fans will eat at restaurants near the stadium, either before or after the game, providing a needed boost to the struggling neighborhood around the stadium.
- Finally, WLS projects that 10% of these fans will travel from a town more than two hours away, and will choose to stay in a local hotel after the game.

You have been hired by the city to provide an impartial analysis of the proposed stadium. As part of this analysis, you have been asked to critique the claims of WLS. Do you agree with the potential benefits? In preparing a cost-benefit analysis, should these benefits be considered? Please explain your answer.

We Like Sports (WLS) is being overly generous by attributing all these benefits to the stadium. First, consider the claim that additional tax revenues will be raised from increased attendance. Here, WLS has ignored the distinction between benefits and transfers. For these revenues to truly be a benefit, they must be new resources coming into the city (assuming that the analysis is being done at the scale of the city). For any new fans that are from the city, this is simply a transfer of money from their pockets to the city's revenues. Moreover, for fans coming from outside the city, this tax revenue is only a benefit if these people would not have visited the city anyway. If increased attendance at baseball games means lower attendance at local theaters, museums, etc., then this is also a transfer. In this case, the baseball team benefits at the expense of other local attractions, and revenues for the city as a whole do not increase (here, I'm assuming that fewer visitors at other attractions means less tax revenue from those places). Similar logic holds for the other claims. While there may be more business at restaurants near the stadium, at least some of this business will come at the expense of other restaurants in the city.

The most likely benefit is the 10 percent that come from more than two hours away. Again, what matters here is whether these people would have visited the city anyway, or whether it is the baseball game that makes them want to come. If they would not come without the new stadium, the revenues brought in by these new fans, both through taxes and through their purchases at local businesses, are a legitimate benefit in the eyes of the city.

**24.** A recent Department of Transportation study shows that purchasing automated safety equipment packages (e.g. automated braking, blind spot detection) reduces the risk of death in a car accident by 1 in 1,500. That is, for every 1,500 people that purchase automated safety equipment when they buy a new car, 1 less person will die in a car accident.

You have been asked to use this information to estimate the value of a life for a cost-benefit analysis on new safety regulations. After careful study, you have determined that the demand curve for automated safety equipment is:

$$P = 8{,}000 - 0.5Q$$

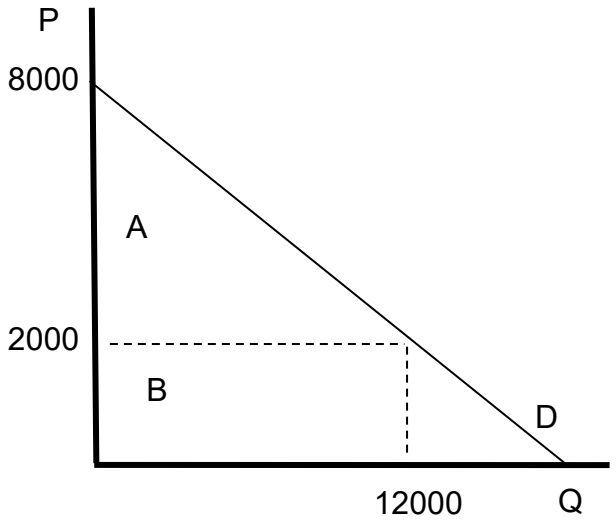
where $Q$ represents the number of car buyers who purchase an automated safety equipment package.

a) Automated safety equipment currently costs \$2,000. At this price, how many car buyers will purchase automated safety equipment? Illustrate on a graph.

To find the number of buyers purchasing safety equipment, simply replace $P$ with \$2,000 and solve for $Q$:

$$2{,}000 = 8{,}000 - 0.5Q$$
$$6{,}000 = 0.5Q$$
$$Q = 6{,}000/0.5$$
$$\boldsymbol{Q = 12{,}000}$$

The graph is shown below, along with the areas necessary to find willingness to pay in part (b).



b) What is the total willingness to pay for the number of automated safety packages purchased that you found in part (a)?

The willingness to pay for 12,000 safety packages equals the total expenditure on safety packages (area B) plus consumer surplus (area A). The value of each is:

area A = consumer surplus = 0.5(8,000-2,000)(12,000) = $36,000,000
area B = expenditure = (2,000)(12,000) = $24,000,000
Willingness to Pay = A + B = **$60,000,000**

c) Based on the results from the Department of Transportation study, how many lives will be saved if this number of safety packages are purchased? Using this information and the total willingness to pay found in part (b), calculate the value of a life saved to a typical car buyer.

For every 1,500 safety devices purchased, one life is saved. We simply divide the total number purchased by 1,500 to find the number of lives saved. This gives us **8 lives saved** (= 12,000/1,500).

Since the community as a whole is willing to pay $60,000,000 to purchase these safety devices, they are willing to pay $60,000,000 to save 8 lives. Dividing $60,000,000 by 8 lives saved yields a value of **$7,500,000** per live saved.

A common error here was to divide $7,500,000 by 12,000, since 12,000 safety devices are purchased. Note that the willingness to pay per person (e.g. $60,000,000/12,000) is $5,000. Moreover, what each person is buying is a 1/1,500 reduction in risk. $7,500,000/1,500 equals $5,000. Thus, consumers are willing to pay up to $5,000 to reduce the risk of death by 1 in 1,500. $7,500,000 represents what an individual would be willing to pay to completely reduce their risk of death.

**25.** Suppose that the city of Lawrence is debating whether to begin a two-year project designed to fix up the streets of Lawrence. They will spend $500,000 on labor now, and an additional $500,000 next year. In addition, the city must also pay out an additional $100,000 this year to purchase materials for the project.

The present value of the benefits generated by better-quality roads is estimated to be $1 million. The city uses a 5% discount rate to evaluate all public projects.

a) What is the present value of costs associated with the project?
b) Is the project admissible? Why or why not?

a) The formula for the present value of the costs is:

$$PV = C_0 + \frac{C_1}{(1+r)}.$$

In this case, the project involves a $600,000 cost in year 0, and a $500,000 cost in year 1. The present value is:

$$PV = 600{,}000 + \frac{500{,}000}{(1+0.05)} = \$1{,}076{,}190.50$$

b) A project is worth doing if the present value of all costs is less than the present value of the benefits, which is given as $1 million. Since that is not the case here, the project is not admissible.

**26.** Consider two projects. The first has a large setup costs, but provides larger benefits afterwards. The second involves no set up, but provides only minimal net befits each year. The net benefits of each project in each year are listed below:

| Project | Year 0 | Year 1 | Year 2 | Year 3 |
|---|---|---|---|---|
| A | -$200 | $100 | $100 | $100 |
| B | $100 | $100 | $100 | -$250 |

You may assume that all values are presented as real dollars.

a) Suppose that the real discount rate is 3%. Which project is preferable? Why?
b) Suppose that the real discount rate is 7%? Which project is preferable? Why?
c) Explain intuitively why the results differ in parts (a) and (b).

a) In each case, we need to calculate the net present value of each project. For each discount rate, we will select the project with the highest net present value. We use the following formula to calculate the net present value. Note that costs or benefits that occur in year 0 are not discounted. Future benefits and costs are discounted as appropriate. In each case, we are given net benefits for a given year, and discount that value as appropriate. Thus:

$$NPV = FV_0 + \frac{FV_1}{(1+r)} + \frac{FV_2}{(1+r)^2} + \frac{FV_3}{(1+r)^3}$$

where $FV_t$ is the future value of the net benefit in year $t$.

We begin by using the above formulas with a discount rate of 3%:

$$PV_A = -200 + \frac{100}{(1.03)} + \frac{100}{(1.03)^2} + \frac{100}{(1.03)^3} = -200 + 97.09 + 94.26 + 91.51 = \$82.86$$

$$PV_B = 100 + \frac{100}{(1.03)} + \frac{100}{(1.03)^2} - \frac{250}{(1.03)^3} = 100 + 97.09 + 94.26 - 228.79 = \$62.56$$

The net present value is higher for option A than for option B. Given this **option A** is preferable.

b) We repeat the calculations with a discount rate of 7%:

$$PV_A = -200 + \frac{100}{(1.07)} + \frac{100}{(1.07)^2} + \frac{100}{(1.07)^3} = -200 + 93.46 + 87.34 + 81.63 = \$62.43$$

$$PV_B = 100 + \frac{100}{(1.07)} + \frac{100}{(1.07)^2} - \frac{250}{(1.07)^3} = 100 + 93.46 + 87.34 - 204.07 = \$76.73$$

The net present value is higher for option B than for option A. Given this **option B** is preferable.

c) A higher discount rate means that people place less importance on future outcomes. In option A, the costs are paid up-front, but the benefits come later. With a high discount rate (part b), these benefits are less important. In contrast, the future benefits receive more weight in part a.

Recall that the discount rate relates to interest rates. In part a, with a lower discount rate, the opportunity cost of having money now, rather than in the future, is lower. Thus, paying the up-front cost is not costly. In contrast, if alternative investments could earn a 7% return, paying the costs up-front, rather than investing them elsewhere, is costly.