

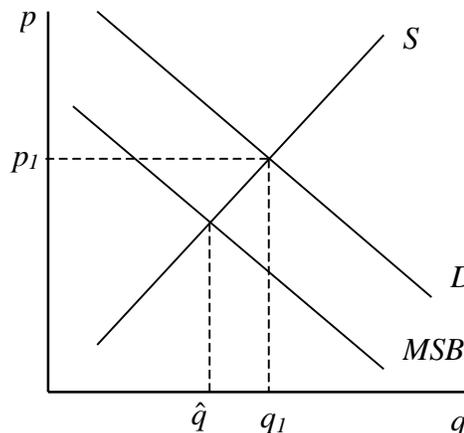
Name:
Student No.:

SPP/Econ 573
Benefit-Cost Analysis
Final Exam - Answers

April 26, 2000

Answer all questions on these sheets. In questions where it is appropriate, **show your work**, if you want partial credit for an incorrect answer. Point values of the questions are shown; there are a total of 61 points possible.

1. (11 points) The figure shows the supply and demand curves for a good (in a closed economy), together with another curve representing the marginal social benefit from consuming the good (MSB). Answer the following questions:



- a. (2 points) What is the nature of this externality? Is it positive, or negative, and is it associated with production or consumption?

Ans: It is a negative externality, since it causes the social benefit from consumption to be less than the private benefit. It is apparently associated with consumption, since it is drawn as shifting the demand curve, not supply. However, in this closed economy we can't really be sure, since every unit produced is consumed, and it therefore it wouldn't matter, even for an externality from production, whether the externality were added to cost or deducted from benefit.

- b. (2 points) If the government does not intervene in this market, what will be the equilibrium price and quantity? Find them in the figure and label them p_1 and q_1 .

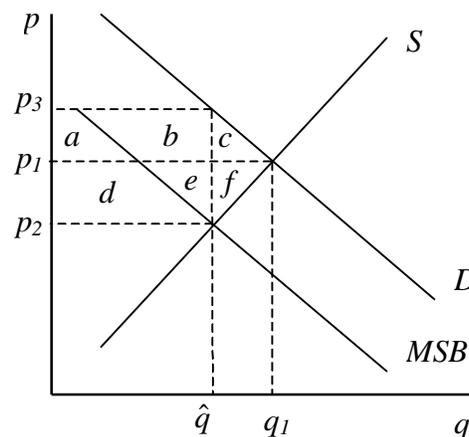
Ans: They are at the intersection of S and D.

- c. (1 point) What level of output is socially optimal in this industry? Find it and label it \hat{q} .

Ans: It is at the intersection of S and MSB.

[The figure from page 1 is reproduced here for your convenience. You should redraw the lines and labels that you added to it on page 1, for use in answering the questions below.]

- d. (2 points) Which of the following policies could be used to achieve this optimum?
- A direct restriction on output, permitting firms to produce no more than \hat{q} .
 - A direct restriction on consumption, permitting demanders to buy no more than \hat{q} .
 - A tax on sellers equal to the size of the externality.
 - A tax on buyers equal to the size of the externality.

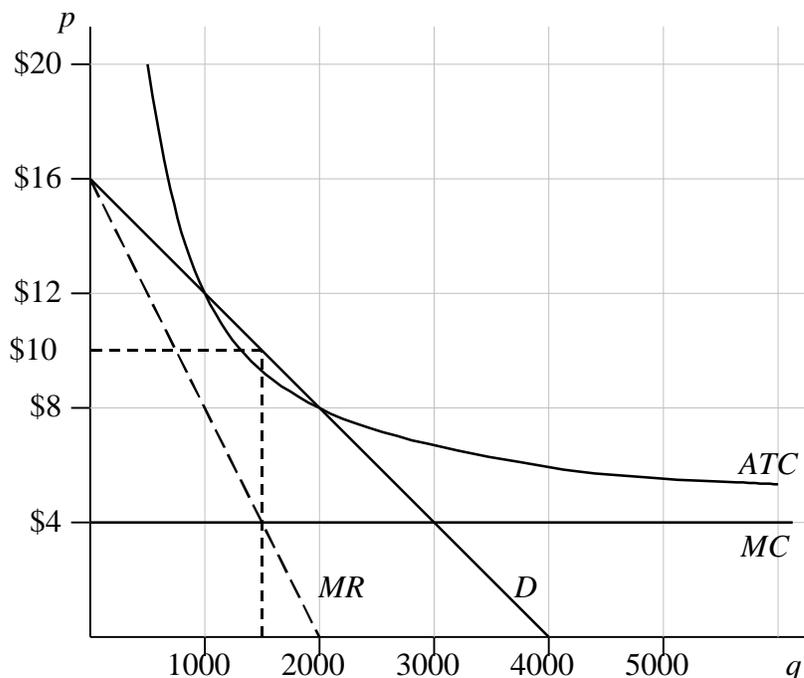


Ans: All four of these policies would work.

- e. (4 points) For each of the policies listed in part (d), determine the effect on the welfare of producers of using that policy, starting from the free market solution of part (b). Add lines and labels to the figure above as necessary to identify the contributions of welfare, and use these in your answer.

Ans: Policies ii-iv all have the effect of reducing the price that the sellers get, from p_1 (at the intersection of S and D) to p_2 (at the intersection of S and MSB). For the tax on either sellers or buyers, this happens by creating a wedge between buyers' price, p_3 , and sellers' price, p_2 , equal to the tax. For the quantitative restriction on consumption it happens by forcing the demand curve to become vertical at \hat{q} . Either way, the suppliers suffer a loss of producer surplus equal to the area left of S between p_1 and p_2 : $-(d+e+f)$. The quantitative restriction on suppliers is different, however, for it causes the market price to rise to, p_3 , where the quantity demanded equals \hat{q} . Suppliers therefore get all of the rents from the restriction. They still lose the producer surplus they earned before on output above \hat{q} , area $-f$, but they now gain the increase in price on all the units up to \hat{q} , $+(a+b)$, which in this case appears to be quite a bit more. That is, producers net gain is $+(a+b)-f$.

2. (12 points) Production of fluffles has a constant marginal cost of \$4.00 per fluffle, but any producer must also bear a fixed cost of \$8000 independent of the number of fluffles produced. Demand for fluffles is given by the demand curve $Q=4000-250P$.
- a. (2 points) Draw the marginal and average (total) cost curves of a single fluffle-producing firm. (Hint: note particularly the levels of average cost at outputs 1000, 2000, and 4000.)



- b. (2 points) Add to your diagram the market demand curve for a single firm, being careful about relevant intersections. Can a single firm can break even or make a profit in this market?

Ans: Yes. Since the demand curve lies above the ATC curve for outputs between 1000 and 2000, it is possible for a single firm to make a profit.

- c. (2 points) If there were two firms producing in this market, could they both make a profit?

Ans: No. An easy way to see this is to note that the maximum amount that demanders will spend on this good is at the midpoint of the demand curve, where expenditure (price times quantity) is equal to \$16,000. Since that is the level of fixed costs for two firms, it leaves nothing left over to cover marginal costs. Therefore two firms cannot possibly both make a profit.

- d. (2 points) If there were only one firm, and if it were required to produce whether it made a profit or not, but it could produce and sell any positive quantity it liked, how much output would it produce and at what price would it sell it?

Ans: Such a monopoly firm would maximize profit by operating where marginal cost equals marginal revenue. This occurs at quantity=1500, which sells for \$10.

- e. (2 points) What is the socially optimal quantity to be produced? Can a firm make a profit producing that?

Ans: The socially optimal output is where marginal cost equals the marginal benefit, which in this case is just the height of the demand curve. Therefore, the optimum is an output of 3000. At that output, a firm cannot make a profit, since it can only sell it for the price of \$4, which covers only marginal cost and does not cover any of the fixed cost. A firm producing and selling this amount will lose its entire fixed cost of \$8000.

- f. (2 points) Write a short paragraph discussing how society might achieve the social optimum? (Don't waste too much time on this. There isn't necessarily one best answer, and you could probably write a lot here if you had time.)

Ans: A subsidy to output would do the job, but it would have to be set large enough to equate marginal cost to the marginal revenue at the optimal output, 3000. Since MR there is - \$8, the subsidy would have to be \$12 per unit. At that rate, the monopolist producer would earn profit of $\$24,000 - 8,000 = \$16,000$. To avoid the distributional consequences of this, you might want a lump sum tax on the monopolist as well, of up to this amount. Another alternative would be to regulate the price that the monopolist can charge, permitting it to be no higher than \$4, but then the monopolist will lose money and you'll need a lump-sum subsidy of at least \$8000 so that they can break even.

3. (10 points) The city of Peoria is considering building a new park. It has polled the residents and estimated that the population of 750,000 is divided into three groups, members of which would individually be willing to pay the following amounts for the park:

	Number of Residents	Amount each is willing to pay
A:	200,000	\$0
B:	250,000	\$12
C:	300,000	\$100

Based on this information, answer the following questions:

- a. (2 points) If the park can be built for \$15 million, should it be?

Ans: Yes. The total willingness to pay of the population is $250,000(\$12) + 300,000(\$100) = \$33 \text{ mil}$, which is much greater than the cost.

- b. (2 points) If the cost is \$15 million, and if the only way to pay for the park is to divide its cost equally among the entire population, would a majority vote for it?

Ans: No. Divided equally across the 750,000 population, the cost is \$20 per person. At this rate, both group A and group B will vote no.

- c. (2 points) What is the maximum amount that the city **should** be willing to pay for the park?

Ans: That would be \$33 mil, the total willingness to pay of the population added together, since this is a public good.

- d. (2 points) What is the maximum amount that a **majority would** be willing to vote for, if the cost is to be divided equally?

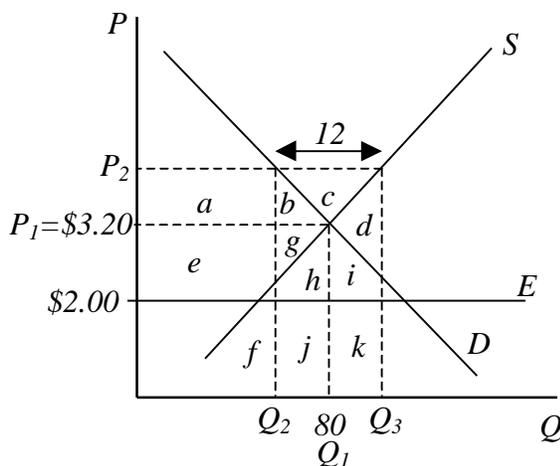
Ans: The highest price per person that group B would vote for is \$12, and at that price they are indifferent. So to get them to vote yes, the price would have to be a tiny bit under that per person. Multiplying by the population of 750,000, this puts the maximum at $750,000(\$12) = \9 mil., or just a shade under that.

- e. (2 points) Write a short paragraph discussing how Peoria might handle the problem of whether to build the park. (Again, don't waste too much time on this. Just say something sensible.)

Ans: Several possibilities come to mind, none of them optimal. If it is possible to charge for using the park, then perhaps it could be financed that way, especially if that makes it possible to charge group C more than group B, perhaps because they use it more often. Of course, that adds the cost of enforcing and collecting the use charge, which reduces the total benefit from the park. Another possibility, if characteristics of the different groups can be identified that are related to their desire for the park (such as having children), they could be taxed differently based on those characteristics. By managing to get the tax on group B less than \$12 while putting it high enough on group C to pay the cost of the park, it may be possible to concoct a package that a majority will vote in favor of. Still another possibility would be for members of group C to form a coalition and tax themselves to pay for the park. This runs into the free-rider problem, and we shouldn't expect it to work, but it is worth a try to the extent that people either behave in the social interest or can monitor each other's behavior and preferences. Finally, one might package the park with other policies that do more for groups A and B than for C, then vote on them as a bundle. This would be, in effect, logrolling.

4. (16 points) Suppose that production of wheat generates a positive externality for society that is known to be worth \$2 a bushel. Initially, the U.S. is producing 80 billion bushels of wheat a year for its (closed) domestic market, where the equilibrium price per bushel is \$3.20. The U.S. government is considering buying 12 billion bushels a year from this market and shipping it to Russia, for an undisclosed price and perhaps other more political remuneration. The question is: what will it cost the U.S. as a country (not just as a government) to do this?
- a. (6 points) In the space below, use supply and demand curves to illustrate the initial equilibrium in the U.S. domestic wheat market and then the effect on it of this government purchase. Based on your diagram and any labels that you find it useful to introduce, identify the costs and benefits of this policy to
- domestic wheat producers (? PS),
 - domestic wheat consumers (? CS),
 - the monetary cost of the wheat to the government (? Gov), and
 - the rest of society via the externality (? Ext).

(Note: You will most likely find it useful to label some areas in the diagram to use for some of this, but probably not for all of it. Feel free to identify these costs and benefits in whatever way is convenient.)



- Ans:
- ?PS = $+(a+b+c)$
 - ?CS = $-(a+b)$
 - ?Gov = $-(b+c+d+g+h+i+j+k)$
 - ?Ext = $+k$

- b. (4 points) Let the elasticity of supply in the U.S. wheat market be 0.8 and the elasticity of demand be (minus) 2.2. Solve for the change in price in the domestic wheat market as a result of this policy, and also the changes in quantities supplied and demanded.

Ans: From the definitions of the elasticities, we have that $\Delta Q_D/Q_0 = -E_D \Delta p/p_0$ and $\Delta Q_S/Q_0 = E_S \Delta p/p_0$. For the market to clear with the government buying 12 units, $\Delta Q_S - \Delta Q_D = 12$. Together these yield $(E_S + E_D) Q_0 \Delta p/p_0 = 12$, or $\Delta p = 12 p_0 / Q_0 (E_S + E_D) = 12(3.20) / 80(2.2 + 0.8) = +\0.16 . Therefore $\Delta Q_D = - (2.2)(0.16)(80) / 3.20 = - 8.8$. $\Delta Q_S = (0.8)(0.16)(80) / 3.20 = 3.2$. Thus $p_2 = \$3.36$; $Q_D^2 = 71.2$; $Q_S^2 = 83.2$.

- c. (4 points) Using your results from part (b), calculate the four changes in welfare identified in part (a).

Ans: All of the following are in billions of dollars:
 $\Delta PS = (0.16)(80 + 83.2) / 2 = \13.056 ;
 $\Delta CS = - (0.16)(80 + 71.2) / 2 = - \12.096 ;
 $\Delta gov = - (3.36)(12) = - \40.32 ;
 $\Delta ext = (2)(3.2) = \6.40 .

- d. (2 points) How much, then, does this wheat for Russia cost the United States?

Ans: $\$13.056 - 12.144 - 40.32 + 6.4 = - \32.960 billion.

5. (8 points) Determine the following present discounted values using the interest rates indicated:

- a. (2 points) The present discounted value, at an interest rate of 5% per year, of \$400 starting three years from now and continuing annually, with the last payment 10 years from today.

$$\text{Ans: } \frac{400}{.05} \left(1 - \frac{1}{(1.05)^{10}} \right) - \frac{400}{1.05} - \frac{400}{(1.05)^2} = \$2345$$

- b. (2 points) The present discounted value, at an interest rate of 12% per year, of a new car that is worth \$25,000 today but on which you must make five annual payments of \$10,000 a year starting one year from now.

$$\text{Ans: } +25,000 - \frac{10,000}{.12} \left(1 - \frac{1}{(1.12)^5} \right) = -\$11,047$$

- c. (2 points) The present discounted value, at an interest rate of 3% per year, of an oil well that yields \$40,000 worth of oil today and continues to produce oil thereafter but with its output of oil declining at 10% a year forever.

$$\text{Ans: } V_c = \frac{(1+r)X}{r+d} = \frac{(1.03)(40,000)}{(0.03+0.10)} = \$316,923$$

$$\text{(or } V_c = X + \frac{X(1-d)}{r+d} = 40,000 + \frac{36,000}{0.13} = \$316,923)$$

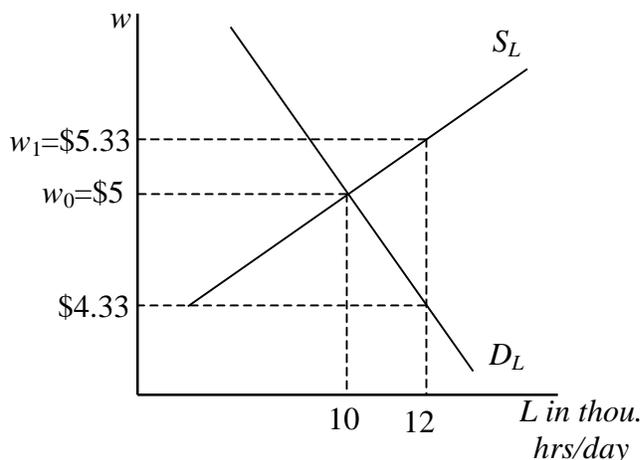
- d. (2 points) Repeat part (c) but with output of the oil well equal to zero starting 11 years from now (that is, output is positive, but declining, for 11 years).

$$\text{Ans: } V_d = V_c - \frac{V_c(1-d)^{11}}{(1+r)^{11}} = \$316,923 \left(1 - \frac{(0.9)^{11}}{(1.03)^{11}} \right) = \$245,075$$

(or

$$V_d = X + \frac{X(1-d)}{r+d} \left(1 - \left(\frac{1-d}{1+r} \right)^{10} \right) = 40,000 + \frac{36,000}{0.13} \left(1 - \left(\frac{0.9}{1.03} \right)^{10} \right) = \$245,075)$$

6. (4 points) In a previous exam, you quantified the effects of a subsidy to employment of unskilled labor in the village of Arbordale. What you found (or should have found) is shown in the graph and in the table below:



Effects of a \$1/hr wage subsidy in Arbordale:

Initial wage	\$5.00 /hour
Initial employment	10,000 hours/day
New wage	\$5.33 /hour
New employment	12,000 hours/day
Cost of subsidy to government	\$12,000 /day
Benefit to unskilled workers	\$3,666.67 /day
Benefit to employers of unskilled workers	\$7,333.33 /day

Now assume, in addition, the following:

- The unskilled workers in Arbordale are regarded as poor, and all others, including their employers and most taxpayers, as nonpoor.
- Another policy exists that can transfer income from the nonpoor to the poor in arbitrary amounts, but for every \$1000 taken from the nonpoor, only \$800 makes it to the poor. The rest is lost in inefficiency, administrative cost, and waste.

Evaluate the wage subsidy.

*Ans: Using the Kaldor-Hicks criterion, the wage subsidy is a bad policy, since it costs the government more (\$12,000) than it benefits workers and employers (\$11,000). However, it helps the poor, and it may therefore be a desirable policy if it accomplishes this better than the other available policy. There are several equivalent ways of determining whether this is the case or not. One is to calculate the break-even weight on the poor (with a weight of one on the nonpoor) for the other redistribution policy. Since the leaky bucket ratio for the redistribution policy is $(1000-800)/1000=0.2$, this break-even weight is $1/(1-0.2)=1.25$. Using this weight on the gains to unskilled workers and weights of one on the employers and the government, we get the net benefit from the wage subsidy as $+(1.25)(3666.67)+(1.0)(7333.33)- (1.0)(12000)=- \83.33 . Another way to get this same result is to note that the wage subsidy takes away a net amount of $-\$12,000+7333.33=- \$4,666.67$ from the nonpoor while giving only \$3,666.67 to the poor. If the other policy were used to take the same amount away from the nonpoor, it would give to the poor $(0.8)(4666.67)=\$3,733.37$, which is more. So the wage subsidy is **not** a good policy, even for redistribution.*

The following problem is completely optional. Don't waste time on it if you could more usefully be working on the rest of the exam. Not doing this optional problem will not count against you.

7. The town of San Wobble lies in a peculiar location where one side of the town (the West Side) is immune from tornadoes while the other side (yes, the East Side) is hit randomly by these storms every few years. Experience suggests that while houses on the West Side last forever, their residents living to ripe old age, the houses on the East Side have a probability of 1 in 2000 each year of being completely destroyed. Being hit by a storm is not always fatal to residents of these houses, but about one in ten hits by a storm causes a fatal injury. A typical house on the safe West Side sells for \$140,000. An otherwise comparable house on the unsafe East Side sells for \$126,000 and can be replaced quickly for \$140,000. (These numbers do not include the land, which survives the storm.) The real interest rate is 3% a year.
- a. Assuming that residents of San Wobble are risk neutral with regard to loss of property, what is the value that they place on loss of life?

Ans: In any given year, an owner of an East Side house has a 1 in 2000 probability of incurring a \$140,000 property loss (the cost of rebuilding a house destroyed by a storm). If they are risk neutral, they will value this at its expected value, $\$140,000/2000 = \70 , a cost that they or subsequent owners will bear each year forever starting immediately. The present value of that cost is $(1+r)\$70/r = (1.03)(\$70)/0.03 = \$2,403$. Therefore, to compensate them only for this risk of property loss, the value of East Side houses would have to be $\$140,000 - 2,403 = \$137,597$. Since East Side houses in fact sell for \$126,000, the difference of \$11,597 must be compensation for risk of loss of life. Reversing the present value formula just used, this is equivalent to compensation of $(0.03)(\$11,597)/(1.03) = \338 per year. Since the probability of loss of one life is $(1/2000)(1/10) = 1/20,000$ each year, the implied value of a life is $(\$338)(20,000) = \$6,760,000$.

- b. If instead you knew from some other source that they value their lives at \$5 million, how would the certainty equivalent of the loss of property value from a storm compare to his expected value? Are residents risk averse or risk loving?

Reversing the above calculation, a \$5 million value of life would require compensation of $\$5,000,000/20,000 = \250 per year, which has a present value (repeated every year starting today) of $(1.03)(\$250)/(0.03) = \$8,583$. Thus only this much of the \$14,000 price differential is compensation for risk to life, and the rest, $14,000 - 8,583 = \$5,417$ must be the certainty equivalent of the risk to property. Since that is quite a bit larger than the \$2,403 expected value calculated above, we conclude that these residents are quite risk averse.