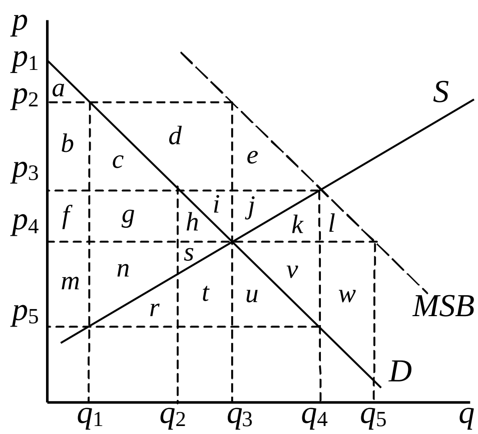
Name:
Student No.:

SPP/Econ 573
Benefit-Cost Analysis
Midterm Exam No. 2 - Answers

April 10, 2000

Answer all questions, on these sheets in the spaces or blanks provided. 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 54 points possible.

1. (16 points) The figure at the right shows private supply and demand, *S* and *D*, in the market for a vaccine. It also shows as a separate curve, *MSB*, the marginal social benefit from use of the vaccine, which is higher than the private benefit because of a positive externality. All the curves are straight lines, and *MSB* is parallel to *D*.



   a. (8 points) Using the quantities, prices, and areas labeled in the figure, identify the following:

      i. The socially optimal quantity to produce. ***q_4***

      ii. The socially optimal price to charge demanders. ***p_5***

      iii. The socially optimal price to pay suppliers. ***p_3***

      iv. The net gain to all of society (including suppliers and demanders) due to moving from the market equilibrium to the social optimum. ***e+j*** (=k+v, etc.)

b. (4 points) In the same market as part (a), suppose now that the government decides to buy some quantity of the vaccine itself and give it away free to certain consumers. Taking account of the effect of this purchase on the market equilibrium, how much of the vaccine should the government buy, and to whom should it give it, in order to achieve the social optimum? For this purpose, assume that each individual can use only one unit of the vaccine, so that the demand curve represents not only the quantity consumed but the number of consumers, and people can be represented by the price they were willing to pay for the vaccine. Thus

Using the "q's" from the figure, how much vaccine should the government buy? **q_4- q_2** ($=q_5-q_3$)

To whom should the government give this vaccine?

The consumers whose reservation prices are **between p_3 and p_5**, or equivalently, those who along the demand curve who would buy units of the good **between q_2 and q_4**. It should **not** give it to those who want it most.

c. (4 points) Returning now to the situation in which the government does **not** buy any of the vaccine, suppose that it instead sets a price ceiling in the market equal to price p_5 in the figure. That is, it makes it illegal for sellers to charge a price higher than p_5 and it enforces the law perfectly. Sellers in turn ration the vaccine by selling it to those consumers who **wait in line** (queue) for it at a pre-announced time and place. Assuming that all consumers have the same cost of waiting in line and that they correctly anticipate the minimum time that they'll need to wait in order to get some of the scarce vaccine,

i. Who will get the vaccine?

Those consumers whose willingness to pay for the vaccine is highest; specifically, **those willing to pay more than p_2.** Or in other words, those in the interval **$[0,q_1]$.**

ii. About how much do these consumers (who get the vaccine after waiting in line) benefit from having it available on these terms, compared to it not being produced at all?

Their benefits range from only zero to p_1-p_2, since the rest of the difference between the price p_5 and their willingness to pay is offset by the cost of waiting in line. The total benefit is area ***a***.

2. (9 points) Determine the following present discounted values using the interest rates indicated:

a. (2 points) The present discounted value, at an interest rate of 2% per year, of $1200 starting two years from now and continuing annually, with the last payment 25 years from today.

PV= $(1200/0.02)[1–1/(1.02)^{25}] – 1200/1.02$ = (1200/0.02)[1–0.6095] – 1200/1.02 = 23430 – 1176 = **22254**.
Equivalently: PV=$(1/1.02)\{(1200/0.02)[1\text{-}1/(1.02)^{24}]$=22252.

b. (2 points) The present discounted value, at a nominal interest rate of 8% and with a rate of inflation of 3%, of a nominal annual payment that is $150 one year from now and that rises thereafter, in nominal terms, at a rate of 6% a year forever.
In Nominal terms: PV= (150/(0.08–0.06) = **7500**.
In Real terms the payment appreciates at a rate of only 6–3=3% and the real interest rate is 8–3=5%: PV = (150/(0.05–0.03) = 7500. (Both of these are actually at next years prices. In today's prices they would be 3% smaller: 7282.)

c. (5 points) The present discounted value, at each of the interest rates listed below, of an investment project that **costs** $12,000 one year from now and yields a **benefit** of $600 every year thereafter (starting two years from now) forever.

i. Interest rate = 4%
PV = –12,000/1.04 + (1/1.04)(600/0.04) = –11538 + 14423 = + **$2885**.

ii. Interest rate = 6%
PV = –12,000/1.06 + (1/1.06)(600/0.06)= –11320 + 9434 = - **$1886**.

iii. How do these answers compare, and why?
The project is not worth doing at the higher interest rate, even though it is worth doing at the lower rate. The reason is that the **benefits all come later than the costs, and the higher interest rate discounts these benefits more**.

3. (9 points) Using the method of required compensation, answer the following questions.

   a. (2 points) Long-distance truckers have a frequency of accidents on cross-country trips of 1.5 accidents per 100 trips. Drivers of tanker trucks, filled with flammable liquids like gasoline, have no more accidents than others, but when they do have accidents, the drivers are more likely to be killed. 1.2% of accidents are fatal to the driver in normal trucks, but 3% of them are fatal to the driver in tanker trucks loaded with gasoline. Knowing this, drivers demand an additional $1200 per cross-country trip to drive such tankers. On the basis of this information, what is the value of a trucker's life?

      Pr(death)=0.015×0.012=0.00018 in normal trucks.
      Pr(death)=00.015×0.03=0.00045 in tankers. Driving a tanker therefore involves an increased probability of dying of 0.00027, or 27/100,000. Since drivers require $1200 to compensate them for this probability, they implicitly are valuing their lives at $1200/0.00027=$1200×100,000/27 = **$4,444,444.**

   b. (2 points) Until recently, out of a population of 150,000 professors in the United States, an average of ten would die every month from White Lung Disease – an affliction brought on by inhaling chalk dust. Recently, some university administrators have begun a move away from using chalk, toward using white boards and markers, or even PowerPoint presentations. Several have replaced all chalk boards and simultaneously reduced the salaries of professors by $1000 a year because of the reduced need to compensate for risk. The price was apparently right, since few professors have sought to transfer either into or out of those universities that have adopted this policy. Again, on the basis of this information, what is the value of a professor's life?

      Since 120 professors were dying every year (ten a month) out of a population of 150,000, the probability of dying seems to have been 120/150,000=0.0008 per year. Since $1000 was enough to compensate them, they apparently valued their lives at $1000/0.0008=$1000/$1000×150,000/120 = **$1,250,000.**

c. (3 points) Give three reasons why one or both of the estimates in parts (a) and (b) may under- or over-estimate the amount that analysts should use to value the risk of loss of life for the general population.

1. Tanker drivers may self-select because they care less about dying than other people, so that (a) gives an underestimate.
2. Professors may like the smell of chalk dust or have some other reason for preferring chalk over the less risky technologies, so that (b) gives an underestimate.
3. Both groups, but especially the notoriously absent-minded professors, may be ignorant of the risks to their lives, so that both give underestimates.
4. At best, these kinds of calculations make sense only for small probabilities of dying. As probabilities get higher, and especially as they approach one, the numbers should get larger.
5. Both groups may not take into account the suffering of their family members (and students?) if they die, so that the social value of their lives is larger than they think. (Or perhaps others would be glad to see them gone.)
6. The professors may feel that they have not choice but to remain where they are, regardless of this pay differential, since most of them have tenure. If so, the differential could be higher or lower than now they truly value risk. Similarly, their immobility may undermine their bargaining power with the administrators.
7. Some analysts favor use of the Discounted Future Earnings method of valuing life, which would yield a much different answer.

d. (2 points) Using a value of life of $5,000,000 and a value of time of $12/hr (=20¢ per minute), how much extra time should a student be willing to devote to crossing Huron Street to the SPP Annex at a safe crosswalk rather than crossing where it is more convenient and being killed by a car with a probability of one in 10,000,000 (0.0000001).

With a value of life of $5 million a student should be willing to pay that times the probability of dying from an event to avoid that event. Thus they should be willing to pay $5 million/10 million = $0.50 to avoid crossing Huron street in mid-block. With a value of time of 20 cents per minute, this equates to **2.5 minutes**, which is the amount of time they should be willing to spend walking to a safe cross-walk and back.

4. (6 points) Suppose that the best available standard method of redistributing income from the non-poor to the poor has a Leaky Bucket Ratio of 25%. Each of the following represents the effect on the well-being of the non-poor and poor of particular project that is being considered for implementation. Evaluate each of them separately from the standpoint of the leaky bucket ratio: Tell whether each should be implemented or not, and show why.

a. ? Y_N = +1000; ? Y_P = - 800

NO. The most that could be done to compensate the poor here would be to take away 1000 from the non-poor, and with the 25% leaky bucket ratio, this would deliver **only 750 to the poor**, which is not enough.

[Using weights, the break-even weight on the poor that is implicit in the 25% leaky bucket ratio is 1/(1-.25)=1.33. The weighted value of the project is then +1000–(1.33)800=1000–1067= - **67**.]

b. ? Y_N = - 500; ? Y_P = +400

YES. The best that could be done with the leaky bucket policy would be to take 500 from the non-poor and deliver (.75)500=**375 to the poor**, which is worse than this project does.

[Using weights, this project has a net value of –500+(1.33)400=–500+533**=+33**.]

c. ? Y_N = +15,000; ? Y_P = –11,000

YES. Even though the poor lose big from this project, they could be compensated. If we were to take away the full 15,000 from the non-poor, we'd be able to **give the poor 11,250**, which is more than they lose. Or to make everybody win, we could take away slightly less, say 14,800 from the non-poor, and deliver (.75)14,800=11,100 to the poor, so that the non-poor gain 200 and the poor gain 100.

[Using weights: +15,000 – (1.33)11,000=+15,000–14,667= **+333**.]

5. (14 points) The wage of unskilled labor in the village of Arbordale is currently in competitive equilibrium at w^0=\$5 per hour with a quantity supplied and demanded of 10,000 hours per day. At this wage, these workers are among the poorest of the village's population. The elasticity of labor supply in this market is E_S=3.0, while the elasticity of labor demand is E_D=(-)1.5 (demand is downward sloping). In an effort to alleviate the poverty of unskilled workers, the village plans to provide a subsidy to the employment of unskilled labor of \$1 per hour.

   a. (4 points) Calculate by how much the competitive equilibrium wage received by unskilled workers will rise due to this policy.

      In equilibrium, the quantities of labor supplied and demanded are equal: $Q_S=Q_D$. Therefore their changes, which can be calculated from the elasticities and the changes in wages, must be the same as well:
      $? Q_S/Q^0=E_S(? w_S/w^0)=? Q_D/Q^0=–E_D(? w_D/w^0)$, where w_S is the wage received by suppliers (workers) and w_D is the wage paid by demanders (firms). These two wages are equal initially, but after the subsidy the workers get \$1/hr more than the firms pay: $w_S=w_D+1$. Therefore $? w_S= ? w_D+1$, which can be substituted into the above equation to get: $E_S(? w_D+1)=–E_D ? w_D$ (note that w^0 cancels out). Solving yields $? w_D=–E_S/(E_S+E_D)=–3.0/(3.0+1.5)=–3/4.5=–.667$ and
      $? w_S=1–.667=+$\$**.333** for a new wage of **\$5.33/hr**.

   b. (4 points) How much, therefore, is the new quantity of labor supplied (and demanded) with the subsidy, and how much does the village government spend on the subsidy?

      Since the wage has risen from \$5 to \$5.33, a percentage of 6.67%, the supply of labor increases by E_S=3.0 times this, or 20%, from 10,000 to **12,000 hours** per day. The subsidy therefore costs the government \$1(12,000)=**\$12,000**.

c. (4 points) Calculate the amounts by which unskilled workers and demanders of unskilled labor both gain from this subsidy.

The workers gain the increase in producer surplus, the area to the left of the supply curve between the old and new higher wage that they receive. This is ? $w_S(Q^0+Q^1)/2 = (\$0.33)(10{,}000+12{,}000)/2 =$ **$3,666.67**.

The demanders gain the increase in consumer surplus, the area to the left of the demand curve between the old wage and the new lower wage that they pay, $4.33. This is –? $w_D(Q^0+Q^1)/2 = -(-\$0.67)(10{,}000+12{,}000)/2 =$ **$7,333.33**.

(Note, though you are not asked about this, that these two gains sum to $11,000, which is less than the $12,000 cost of the subsidy to the government, due to the dead weight loss caused by the subsidy. You'd have been wise to check this.)

d. (2 points) Using your knowledge of how markets work, explain whether and under what circumstances you would be able to recommend this policy. You **not** need to do any calculations for this, and indeed you don't even need to have done parts (a-c) at all. Just indicate the nature of any calculation that you **would** do if you had enough information.

In competitive markets, as this one is, we know that any market intervention such as this subsidy will cause dead-weight losses and will therefore not increase net welfare based on a Kaldor-Hicks test, and the answers to parts (a-c) should have confirmed this). However, presuming that unskilled workers are among the poor of this community, it may be that the community would agree on the need to redistribute income toward them. If available policies for doing this are costly or inefficient (the leaky bucket idea), then it is possible that this wage subsidy might do a better job of redistribution than other available alternatives. To find out, we would need to know either the leaky bucket ratio for these alternatives or the weight, compared to the non-poor, that this community is willing to apply to income changes for these unskilled workers. We would then compare it to the gain they derive from the wage subsidy, together with the gains for the labor demanders (presumably not poor) and the costs to the village government.