SUID:

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Exam 3
Fall 2024

DO NOT OPEN THIS EXAM UNTIL YOU ARE TOLD TO DO SO.

Instructions

1. Write your SUID in the upper right corner of this exam. **DO NOT WRITE YOUR NAME**.

2. **SHOW ALL YOUR WORK**. Answers without supporting work will receive little or no credit.

3. There are 120 points on the exam and you'll have 180 minutes to complete it. Be sure to budget your time accordingly.

4. Some questions provide a blank table you can use to organize your calculations. Be sure to label the columns clearly. Where applicable, show the equation for the column in the bottom row of the table. The tables may have more rows or columns than you need.

5. Do all your work on the exam. If you need extra space, write on the backs of the pages. However, if you do write an answer on the back of a page, be sure you've **NOTED THAT NEAR THE QUESTION.**

6. Unless otherwise indicated, use an interest rate of 5% in PV calculations and assume the decision maker is risk neutral and cares only about maximizing EV in calculations involving uncertainty.

7. Some potentially helpful formulas and equations:

$$\frac{1}{2}bh \qquad\qquad \frac{F_t}{(1+r)^t} \qquad\qquad \frac{F}{r}$$

Question 1 (15 points)

A government would like to build a large new bridge and is considering two options for constructing and paying for it: C and P. Option C is conventional financing and the government would construct the road itself using tax dollars. Construction would cost $20 million per year for 5 years (years 1-5). Beginning in year 6, the bridge would be free and would provide $15 million in benefits (consumer surplus) to drivers forever (year 6 on). Under option P, the government would partner with a private company to build a toll bridge. The government would pay $5 million per year of the construction cost and the private company would pay the other $15 million. In exchange, the company would be allowed to charge tolls of $7 million per year (producer surplus) for 20 years (years 6-25). During the toll period, the net benefit to drivers would drop to $7 million per year. After the toll period, the net benefit to drivers would rise to $15 million forever (year 26 on). Under either plan the government would raise its part of the construction cost using a tax with a deadweight loss of $0.20 per dollar of revenue.

Please calculate □ the net present value of each plan (C and P) to the government and □ the NPV of P to the private firm. Then □ indicate which one produces the largest overall NPV to the government and firm together (social surplus). You may assume that both the government and the firm use an interest of 5% in present value calculations. *Extra credit: □ explain briefly what causes the winning plan to beat the alternative.*

Question 2 (15 points)

Errors in medical care are the third largest cause of death in the United States after heart disease and cancer. One action that could help would be improved record keeping in hospitals. Suppose that the government is considering giving $1.25 billion in grants (G) to hospitals to upgrade record keeping technology. However, it is not clear how much the upgrade will help. There is a 70% chance it will be highly helpful ("H") and would provide $2 billion in benefits. However, there is a 30% chance it would only be moderately helpful ("M") and produce $400 million in benefits. However, a trial of the system (T) could be run for $125 million that would indicate for sure whether H or M would occur before the decision needs to be made.

Please ☐ determine what the government should do. Then, ☐ provide a brief intuitive explanation about why your recommended approach is better than the next best alternative. To keep things simple, all the numbers above are already present values so no NPV calculations are needed: treat it as a simple one-time decision with no time dimension.

Question 3 (15 points)

Improving agricultural practices is a promising way to address climate change. However, not all practices work equally well on all farms. This question explores a stylized example of the issue.

Suppose there are three possible farming practices: conventional farming (C); reduced fertilizer use (F); and improved tillage and planting (P). To keep things simple, assume the practices can't be combined: farms use either C, F or P. When F and P work well, farmers earn carbon credits they can sell and thus earn higher profits. However, F and P also raise costs, and can reduce profits if they don't work well. How well each technique works depends on a characteristic of each farm (call it the farm's type) that is initially unknown and can take three values, 1, 2 or 3. The table below shows the overall payoff (including costs and revenue from any carbon credits) from using each practice on each type of farm as well as the probability that a given farm is a particular type.

Type	Probability	Practice Used		
		C	F	P
1	40%	$500 k	$400 k	$300 k
2	40%	$500 k	$600 k	$400 k
3	20%	$500 k	$600 k	$700 k

Finally, suppose a test (T) is available that would allow a farm to determine its type before choosing a practice. What is the maximum amount a farm would be willing to pay for the test?

Question 4 (15 points)

A school district with an aging fleet of diesel buses is considering two options for replacing them. Option N would use buses powered by natural gas. It would cost $5 million in year 0, last for 20 years (years 1 to 20), and produce $750,000 of benefits every year in reduced fuel costs and lower pollution. Option E would use electric buses instead. It would cost $12 million in year 0, last for 20 years (1 to 20), and produce $1.25 million of benefits each year in lower fuel costs, lower pollution, and cheaper maintenance. However, the district is aware that the cost of electric buses may fall as the technology develops. It believes there is a 50% chance that in 5 years the cost of option E will drop to $8.25 million (otherwise it will remain $12 million). The district could continue using the diesel buses and wait to make the decision about new buses in year 5 after it is clear whether or not the price falls. If it does so, the cost would occur in year 5 and the benefits would arrive in years 6 to 25.

Using an interest rate of 5% in present value decisions, please evaluate the options and determine what the district should do.

Question 5 (15 points)

A nonprofit organization provides cyber security consulting to small businesses. It has total costs given by the following equation: $TC = 6000 + 10Q^2$ where Q is the number of businesses it serves. It believes the demand for its service is given by $WTP = 1050 - 5Q$, and there are no other organizations nearby providing a similar service. The organization wishes to serve as many businesses as possible without running a deficit.

What price should the organization charge and how many businesses will it be able to serve? How much profit will it earn? As a hint, the value of Q is between 60 and 70, inclusive.

Question 6 (15 points)

Suppose a profit-maximizing firm is considering a research project to develop a new method to make steel without producing carbon dioxide emissions. If it succeeds, it would face an annual demand given by $WTP = 15250 - 150 * Q$ and production costs would be given by $TC = 250 * Q$. Assuming that the firm is able to develop the method, what price would it charge and what quantity would it produce in each year during the time it is a monopolist? What profits will it earn each year? As a hint, the quantity will be between 46 and 56, inclusive.

In case you're interested, steel manufacturing currently accounts for about 10% of worldwide CO_2 emissions and a firm in Sweden recently developed a very low carbon process.

Question 7 (15 points)

Now suppose there are two approaches the firm could use for developing the method. Approach L (low cost, low probability) would cost $1 million (paid in year 0) and has a 25% chance of success. Approach H (high cost, high probability) would cost $3 million (paid in year 0) and have a 60% chance of success. Which approach, if any, would the firm use? With either approach, if it succeeds in developing the low-carbon method it would be a monopolist for 20 years (years 1-20) after which other firms would enter, the price would fall to $250 and the firm's profits would drop to 0. If the firm's chosen approach fails, the project fails and the firm would earn no profits in any year.

(a)   Using an interest rate of 5%, please: ☐ calculate the PV of the monopoly profit if the project succeeds; and then ☐ determine which development approach, if any, the firm would use. You may assume the firm will use at most one approach (i.e., not both L and H).

Question 7, continued.

(b)   Now suppose that by reducing carbon emissions, the new steel-making method would create a positive externality of $1000 for each unit of steel produced. Please calculate: □ the external benefits and consumer surplus produced each year during and after the patent period if the firm successfully develops the method. Then, using an interest rate of 5%, calculate □ the PV of the external benefits and CS. (No probabilities needed here: just calculate the payoff if the research works.)

Question 8 (15 points)

Now suppose the government is considering offering a $2 million grant to the firm if it uses development approach H. The firm would receive the $2 million if it undertakes approach H whether or not it actually succeeds in developing the steel-making method. Please: ☐ determine whether the grant would change the firm's decision. Then, using an interest rate of 5%, ☐ determine the government's expected NPV payoff assuming it only cares about the externalities, consumer surplus, and its own payments under the policy (that is, it doesn't care about the firm's profits). Finally, ☐ how much, if anything, would the government gain under the grant policy relative to the expected NPV payoff it would receive without it (i.e., if the firm uses the approach it would choose without the grant). Please be sure to show your work.

Have a great break!

Additional page for calculations
If you use this, please remember to indicate near the question that part of the answer is here.