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Exam 3
Fall 2018

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. Some potentially helpful formulas and equations:

$$\frac{1}{2}bh$$

$$\frac{F_t}{(1+r)^t}$$

$$\frac{F}{r}$$

Question 1 (15 points)

A mid-sized city is concerned about flooding in one of its residential areas. Currently, the area experiences \$450,000 of damage each year. The city is considering two policies, L and P, to address the problem. Policy L would build a system of levees (flood barriers) that would reduce the damage. Construction would cost \$600,000 per year in years 1-5. In year 6, flood damage would be reduced to \$200,000 per year, and it would remain at that level forever. Under Policy P the city would buy up some of the houses and then build a park that would work as a retention basin during floods (a place where the water could pool without causing damage). Buying the houses would cost \$500,000 per year in years 1-5, and building the park would cost \$200,000 in years 6-10. Starting in year 11, annual damages to the residential area would drop to \$100,000.

Please determine which policy, if any, the city should adopt. You may assume that it uses an interest of 5% in present value calculations.

Question 2 (15 points)

A large government agency is considering an upgrade to its computer network. The upgrade would cost \$5 million per year for years 1-5. The \$5 million would be raised via a tax that has a deadweight loss of 0.25 dollars per dollar of revenue. The agency would begin receiving benefits in year 6, and you may assume for simplicity that they would go on forever. However, the agency is unsure about the magnitude of the benefits. There's a 60% chance they would be \$2 million per year (state H), and a 40% chance they would be \$1 million per year (state L). Finally, the agency could hire a consulting firm to determine whether the benefits would be H or L before deciding whether or not to proceed. The firm's results would be available immediately and could be used as in year 0 when the agency is making its decision.

Please determine the maximum the agency would be willing to pay for the study. You may assume the consulting firm is infallible. The city use 4% (four percent) in PV calculations.

Question 3 (15 points)

A city is about to upgrade its street lights to save energy, and it is considering whether or not to install advanced networking infrastructure at the same time. Call the basic upgrade “B” and the version with the networking infrastructure “N”. Installing B would cost \$45 million in year 0 and would produce annual benefits of \$2 million starting in year 1 and lasting forever. Installing N would cost \$60 million in year 0 and its benefits would be uncertain. There is a 75% chance it would produce the same benefits as B: \$2 million every year forever. However, there is a 25% chance that a new technology “T” would become available that would use the network infrastructure and would make the upgrade much more valuable after year 4: the benefits would be \$2 million in years 1-4 and increase to \$3 million per year starting in year 5. The city could also wait to make the decision until it sees whether technology T is developed. If it does that, the installation would occur in year 4 and benefits would begin in year 5 (\$2 million if T was not developed and \$3 million if it was).

The city uses an interest rate of 4% (four percent) in present value calculations and it chooses policies that maximize expected value. Please evaluate its options and determine what it should do.

Question 4 (15 points)

States are sometimes called the “laboratories of democracy” because they can try out new policies at a smaller scale than the federal government. Policies that work well at the state level can then be adopted later by the federal government. This question explores that idea.

Suppose the federal government is considering a new policy that would cost \$10 billion. If the policy works well (state FW, for “federal, works well”), the benefits would be \$15 billion. However, if it works poorly (state FP, “federal, works poorly”) the benefits would only be \$1 billion. A large state is also considering adopting the policy. The state is about a tenth of the country (think California) so its costs and benefits would be a tenth the size: \$1 billion to adopt the policy, \$1.5 billion of benefits if it works well at the state level (state SW), and \$100 million if it works poorly at the state level (state SP). Initially, not much is known about whether the policy will work and analysts think the probabilities are 50/50 for both jurisdictions (FW, FP, SW and SP are all 50%).

- (a) 3 points. Calculate the expected value of adopting the policy at both levels and indicate whether either jurisdiction would proceed ahead.

Question 4, continued.

Now suppose that the state could go first and its outcome (SW or SP) would provide much better information about what would happen at the federal level. In particular, suppose that if the state acts and the policy works well (SW occurs), the policy would have a 90% chance of working well at the federal level. At the same time, if it works poorly at the state level (SP occurs), it would have a 90% chance of working poorly at the federal level. Because it would provide useful information, the federal government is considering offering the state a \$300 million grant to adopt the policy.

- (b) 12 points. Calculate the new expected value to the state if the federal government offers the grant. Would it adopt the policy? Then calculate the expected value to the federal government of waiting to see how the state policy performs and then deciding whether or not to go ahead with the federal version. You may assume that all of this can be done in one period so no PV calculations are needed.

Please note that the analysis of the federal policy should include the cost of the state grant. However, to keep things simple you do not need to adjust the benefits of the federal policy for any benefits received by the state: i.e., if SW happens and is then followed by FW, the federal benefit is still \$15 billion, not just the part left over after the state gets its benefit (which would be \$13.5 billion).

Question 5 (15 points)

A non-profit organization provides advice to small businesses on using social media. It has total costs given by the following equation: $TC = 3000 + 20 * Q^2$, where Q is the number of businesses it serves. It believes the demand for its advice is given by $P = 2100 - 50 * Q$, 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 23 and 33, inclusive.

Question 6 (15 points)

Efforts to control global carbon dioxide emissions over the last 25 years have fallen far short of what's needed to head off climate change. As a result, attention has begun to focus on developing new "direct air capture" (DAC) technologies that could remove carbon dioxide from the atmosphere. At the moment, these technologies are too expensive to be used at large scale. If a new, less expensive, technology could be developed it would be very valuable.

Suppose a profit-maximizing firm is considering a research project to develop a new DAC technology. If it succeeds, the annual demand for the technology would be given by $P = 9,000 - 100 * Q$ and production costs would be given by $TC = 1000 * Q$. Assuming the firm is able to develop the technology, 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 35 and 45.

Question 7 (15 points)

Now suppose the research project in Question 6 would cost \$600,000 and only have a 20% chance of producing a marketable technology. To keep things simple, assume the research can be carried out in year 0. If the project succeeds, the firm would be able to sell the technology and be a monopolist for 20 years (years 1-20). After that, other firms would enter the market, the price would fall to \$1000, and the firm's profits would drop to 0.

- (a) Please calculate the expected net present value of the research project assuming that the firm uses an interest rate of 5% in present value calculations. Should the firm undertake it?

Question 7, continued.

- (b) The government is interested in the potential consumer surplus the technology would produce. Using an interest rate of 5%, what is the PV of the CS that would be generated if the firm successfully developed the technology? Be sure to consider both the period of the patent and the period after the patent expires and competitors enter the market. Finally, account for the fact that the project might not succeed by computing the expected CS.

Question 8 (15 points)

Finally, suppose the government decides to make the project more attractive by offering a \$2 million prize for the technology. If the firm succeeds in developing the technology, it would receive the \$2 million in year 0. If the project fails, the firm receives nothing.

Would this policy induce the firm to undertake the project? Assuming for simplicity that the government only cares about consumer surplus and its payments to the firm (that is, assuming it doesn't care about the firm's profits), what is the government's expected value from the policy above?

Additional page for calculations

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