SUID:

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Exam 3
Spring 2019

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:

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

Question 1 (15 points)

Climate change affects rainfall patterns and will have important impacts on agriculture. Suppose a small community now earns $1 million a year from a given crop, and can continue to do so for 20 years (years 1 to 20). After that, however, degradation of the soil combined with climate change will make it impossible to grow the crop any more (year 21 on).

The community is considering two adaptation policies. To provide plenty of space for the analysis, one will be described on this page and one on the next page. Please determine which policy, if any, the community should adopt. You may assume that it uses an interest of 5% in present value calculations.

Policy C would focus on developing a new crop that could be grown in place of the current one. The new crop would earn $0.9 million per year forever. Development would cost $1.2 million per year and would take 5 years. However, since the new crop would be less profitable than the current one, the community would wait to develop it until close to the time it will be needed: development would occur in years 16-20 and the new crop would be used starting in year 21.

Question 1, continued

Policy P, in contrast, would stick with the current crop but would change farming practices as soon as possible to make it more sustainable and prevent the soil from being degraded. It would cost $0.2 million per year for 5 years (years 1-5) to train farmers in the new practices. Starting in year 6, the farmers would use the improved practices and earn $0.9 million per year forever. The annual earnings would be lower due to the costs of the new methods but they would continue forever rather than ending in year 20. To keep things simple, you may assume that during the training period the farmers use the traditional practices and earn $1 million per year: the switch to $0.9 million occurs at year 6.

Question 2 (15 points)

A university researcher has an idea for a new startup company. To pursue the idea, the researcher would have to quit a job that pays $100,000 in order to work full time on the startup. However, the startup is risky: there's a 20% chance it would succeed (S) and be worth $1 million, but an 80% chance it would fail (F) and be worth only $10,000. The researcher makes decisions by maximizing expected utility and has a utility from a payoff of x dollars given by $u(x) = x^{0.5}$. Finally, everything happens in one year in this problem: no PV calculations are required.

(a) 7 points. Please calculate the expected value of the startup. Then determine whether the researcher will launch the startup or stick with the $100,000 job. Finally, calculate the certainty equivalent of the startup and briefly discuss how it compares with the expected value.

Question 2, continued

(b) 8 points. Now suppose a venture capitalist (VC) appears on the scene. The VC offers to pay the researcher $30,000 to pursue the startup in exchange for 30% of the $1 million payoff if the project succeeds. The VC will receive nothing if the project fails. The $30,000 would be paid regardless of whether S or F occurs. Please determine whether or not the researcher would accept the offer. Be sure to show your work.

Question 3 (15 points)

A city with a large refugee population currently delivers services to the refugees via a collection of separate programs run by different agencies (call that policy "C"). Together the programs produce $36 million in net benefits each year. The city is considering integrating the services into a single agency (call that approach policy "S"). Integrating the services would require a one-time outlay of $50 million, which would be paid in year 0. The annual benefits from S would begin in year 1 and go on forever. However, the value of the benefits is uncertain: there is a 60% chance they would be high (H) and equal to $40 million but a 40% chance the would be low (L) and equal to $20 million. Finally, the city could also hire a consultant to determine whether H or L would occur before it decides on whether to adopt S. To keep things simple, you may assume the consultant would be infallible and would report back in period 0 before the city has to decide on S.

Please determine how much, if anything, the city would be willing to pay for the consulting report. You may assume the city is risk-neutral, and that it uses an interest rate of 5% in present value calculations.

Question 4 (15 points)

One proposal for addressing climate change is to spray small reflective particles known as aerosols into the stratosphere to reflect a portion of incoming solar radiation (policy "SA" for short). Volcanic eruptions, which have a similar impact over short periods of time, suggest that it could work. However, very little is known about whether the technique would be safe for long term use.

Suppose that SA would have one of two outcomes, G or B, and both are believed to be equally likely (each probability is 50%). Under outcome G (good), SA would have a payoff of $100 billion, while under B (bad) it would create severe side effects on the environment and would have a payoff of -$200 billion (note the negative sign). These and all other dollar amounts in the problem will be given as NPVs so there is no need to do additional PV calculations.

(a) 3 points. Please determine the expected value of SA. Assuming the government is risk-neutral, would it undertake it?

Question 4, continued.

(b) 12 points. Now suppose a research project has been proposed to determine whether G or B would occur before SA is undertaken. However, the research project is not infallible: there is a 10% chance that it would report that SA would be bad (rB) when it would actually be good (G), and a 30% chance that it would report that SA would be good (rG) when it would actually be bad (B). The project would cost $5 billion. Please determine the expected value of the research project and indicate whether or not it should be undertaken. Be sure to show your work.

Question 5 (15 points)

A non-profit organization provides advice to small businesses on managing their risks through a technique known as enterprise risk management (ERM). It has total costs given by the following equation: $TC = 20{,}000 + 60 * Q^2$, where Q is the number of businesses it serves. It believes the demand for its advice is given by $P = 8000 - 60 * Q$, 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 60 and 70, inclusive.

Question 6 (15 points)

One outgrowth of the Human Genome Project has been research on the development of customized vaccines that help the immune systems of individual cancer patients fight the disease. Each vaccine would be matched to the DNA of the patient's tumors. The challenge is to develop a manufacturing technique for producing such vaccines quickly and inexpensively.

Suppose that a biotech company believes that if it succeeds in developing the manufacturing process, the demand for vaccines would be given by $WTP = 16{,}200 - 200 * Q$ and its production costs would be given by $TC = 200 * Q$. 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, inclusive.

Question 7 (15 points)

Now suppose the research project in Question 6 would cost $1 million and have a 40% chance of succeeding. If it succeeds, however, the firm would have to conduct clinical trials and apply for approval from the Food and Drug Administration (FDA) before the vaccines could be sold. The trials would cost an additional $1 million and would have a 70% chance of leading to FDA approval. To keep things simple, assume the research and testing can all be carried out in year 0. If the project succeeds and the FDA approves the vaccines, the firm would be able to sell them and be a monopolist for 20 years (years 1-20). After that, other firms would copy the firm's manufacturing technology and enter the market. The price of a vaccine would fall to $200 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 vaccines 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 manufacturing technology and sold the vaccines? 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 to the firm by offering it a $800,000 grant to undertake the project. However, the grant would be subject to the condition that the firm would give the government 20% of the present value of its profits if it succeeds in developing marketable vaccines. If the project fails for any reason, the firm would keep the grant money and would not have to pay the government anything.

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.