

Exam 3
Fall 2020

Instructions:

1. The exam is **closed-notes, closed-book** and **no collaboration** is allowed.
2. It should be submitted no later than **3 hours** after your starting time.
3. There are **105 points** possible on the exam and you'll have 180 minutes to complete it.
4. Some questions provide a blank table you can use to organize your calculations. Be sure to label the columns clearly. The tables may have more rows or columns than you need.
5. **Show all your work.** Answers without supporting work will receive little or no credit.
6. Write your answer on paper and then **scan it and submit it** at the end of the exam.
7. Please **number the pages** as you go so you can scan them in the right order.
8. If you have a **tablet**, you can use that instead of paper as long as you can produce a PDF.

Some useful formulas:

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

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

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

Question 1 (15 points)

An individual is concerned about her consumption in two periods, 0 and 1. Her income in period 0 is \$35,000 and in period 1 it will be \$55,000. However, she is considering whether to take one of three training programs, A, B, or C that would raise her future income. The tuition and raise associated with each is shown below. Finally, she would like to have 2.5 units of consumption in period 1 for each unit of consumption in period 0, and she can borrow or save at an interest rate of 25%.

Program	Tuition in 0	Raise in 1
A	\$20,000	\$30,000
B	\$30,000	\$35,000
C	\$40,000	\$60,000

Assuming she can take at most one program, please determine: which one, if any, she should take; how much she consumes in each period; and how much she borrows or saves in period 0. Finally, draw an appropriate diagram showing her intertemporal budget given what she decides about the training, an indifference curve, her equilibrium, and the amount she borrows or saves.

Question 2 (15 points)

It is often argued that large-scale government investment in infrastructure is very attractive during economic downturns because the spending stimulates the economy and low interest rates mean that borrowing is cheap. This question explores the interest rate aspect.

Suppose a large city would like to renovate part of its electric grid. The project would cost \$800 million per year in years 1-10. The renovated grid would begin operating in year 11 and would produce \$400 million in benefits every year forever. The city usually uses an interest rate of 5% in present value calculations. However, a downturn has lowered interest rates a lot and the city is considering using 2% instead.

Please calculate the renovation's NPV at 5% and indicate whether the city would go ahead with the project under normal circumstances. Next, calculate the NPV at 2% and indicate whether the city would go ahead under that interest rate. Finally, if the city's decision would be different, please compare the present values of the costs and benefits under the two cases and use that information to briefly explain why the decision changes. To keep things simple, you should assume that each interest rate applies for the whole analysis (you do not need to worry that the low interest rate would rise later).

Question 3 (15 points)

An important benefit of big data is that it may allow policies to be targeted more precisely. This problem examines how valuable that could be.

Suppose a community is composed of two types of households: a tech-savvy type T (25%) and a more conventional type C (75%). The government would like to encourage households to use less energy and is considering two policies, S and N. Policy S uses a standard one-size-fits-all approach: for both T and C households, it costs \$12 and produces \$20 in benefits. Policy N is a new technology-driven approach that is much more expensive: it costs \$24 per household. It works very well with type-T households and produces \$40 of benefits. For type-C households, however, it performs no better than policy S and produces only \$20 of benefits. Finally, a consulting firm with access to detailed data about each household has developed an analytical test that can determine whether any given household is type T or type C.

Please determine the maximum the city would be willing to pay to test a given household. You may assume the test is infallible, and that the city is risk-neutral and would like to pick the approach that has the best expected value. Note that everything happens in a single year, so no PV calculations are needed.

Question 4 (15 points)

A non-profit organization provides legal advice for low income individuals who would like to start small businesses. It has total costs given by the following equation: $TC = 2,000 + 10 * Q^2$, where Q is the number of individuals it serves. It believes the demand for its advice is given by $WTP = 900 - 30 * Q$, and there are no other organizations nearby providing a similar service. The organization wishes to serve as many individuals as possible without running a deficit.

What price should the organization charge and how many individuals will it be able to serve? How much profit will it earn? As a hint, the value of Q is between 16 and 26, inclusive.

Question 5 (15 points)

Suppose a firm is considering a research project to develop a new type of thin-film solar cell that would be inexpensive to manufacture and could be used for many applications where current solar cells are not practical. If the project succeeds, the demand for them would be given by $WTP = 6,005 - 50 * Q$ and the cost of producing them would be $TC = 5 * Q$. The firm would be able to patent the technology and be the only seller during the patent period. Assuming the firm is able to develop the cells, 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 56 and 66, inclusive.

Question 6 (15 points)

Now consider the steps involved in bringing the product to market. Suppose the research itself would cost \$1 million and there's a 40% chance it would produce a design that would work. If the design works, the firm would need to spend an additional \$1 million retooling its factory to produce the cells. After that, it would be able to collect the monopoly profit. You may assume that the research project and retooling can all be done in year 0 and the firm would be able to collect the monopoly profit in years 1-20. After year 20, other firms would enter the market, the price of the product will drop to \$5, and the firm's profit will drop to 0.

- (a) Assuming the firm is risk-neutral and makes decisions based on expected value, please: construct the firm's decision tree; and determine whether it would undertake the project. You may assume that the firm uses an interest rate of 5% in present value decisions.

Question 6, continued.

- (b) Now consider the potential consumer surplus the technology would produce. Using an interest rate of 5%, what is \square the PV of the CS that would be generated if the firm successfully developed and sold the cells? Taking into account the uncertainties involved, \square what is the expected CS before the firm undertakes the project?

Question 7 (15 points)

Governments sometimes provide incentives for research and development by promising in advance to buy a large amount of the resulting product if the research succeeds. These are known as “procurement policies” and a prominent example is Operation Warp Speed, under which the federal government contracted to buy hundreds of millions of doses of a Covid-19 vaccine before research on developing the vaccine began.

Suppose the government wanted to use a procurement policy to make the solar cell project more attractive. In particular, suppose the government promised to buy as many units during each year of the monopoly period as the firm sells to the public. That is, if the firm sells X units to the public every year, the government would buy another X units every year. The government would pay the monopoly price. The payments would end at the end of the monopoly period.

Please: construct an appropriate decision tree and determine whether the policy would 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?

Extra credit: suppose the government sold its units for \$5 each to people who hadn't bought the product from the firm. You may assume that's done in a way that doesn't affect the firm's sales or profit. How much additional SS would that produce every year? What would it do to the efficiency of the market?

Additional page for calculations

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