Economics 5250/6250 Dr. Lozada
Fall 2017 Final Exam

This exam has 67 points. There are seven questions on the exam; you should work all of them. Most of the questions are worth 10 points but Questions 4 and 6 are worth less and Question 1 is worth 12 points.

Put your answers to the exam in a blue book or on blank sheets of paper.

Answer the questions using as much precision and detail as the time allows. Correct answers which are unsupported by explanations will not be awarded points. Therefore, even if you think something is "obvious," do not omit it. If you omit anything, you will not get credit for it. You get credit for nothing which does not explicitly appear in your answer. If you have questions about the adequacy of an explanation of yours during the exam, ask me.

Answer all of the following seven questions.

1. **[12 points]** The fisheries handout began with three equations:

$$\Pi(H_t, X_t) = TR_t(H_t) - TC(E(H_t, X_t)) \tag{1}$$

$$\sum_{t=0}^{\infty} \frac{\Pi_t}{(1+\delta)^t} \tag{2}$$

$$X_{t+1} - X_t = F(X_t) - H_t\,. \tag{3}$$

   (a) Explain everything in equation (1). That is, explain *what* each symbol means but also explain *why* it appears where it does. Also explain why the left-hand side is equal to the right-hand side.

   (b) Explain everything in equation (2). That is, explain *what* each symbol means but also explain *why* it appears where it does. Also explain how to rewrite the equation without the summation sign $\sum_{t=0}^{\infty}$.
   What is the importance of this equation?

   (c) Explain everything in equation (3). That is, explain *what* each symbol means but also explain *why* it appears where it does. Also explain why the left-hand side is equal to the right-hand side.

   (d) Equations (1), (2) and (3) together played an important role in the fisheries handout. What role did they play together?

   (e) For one type of fishery, (2) is irrelevant. For another type of fishery, (2) is relevant. What are these two types of fisheries? For which one of them is (2) irrelevant and for which one of them is (2) relevant, and why?

   (f) What relevance, if any, do any of these equations (or special cases of these equations) have for exhaustible resource economics?

2. **[10 points]**

   (a) Sketch a graph of total profit (at some arbitrary date "t") on the vertical axis and quantity of exhaustible resource extracted (at the same date "t") on the horizontal axis. Explain why you think the graph looks like it does.

(b) If a firm maximized short-run profit, where would it be on this graph?

(c) If a firm obeyed the Hotelling Rule, where would it be on this graph as time goes on? Why?

(d) Using this graph, answer the following question: if a firm obeyed the Hotelling Rule, what would happen to its total profit as time went on? Why does behavior of total profit make intuitive sense? (So you are supposed to defend the Hotelling Rule here. Sometimes I ask students to express skepticism about the Hotelling Rule, but I am not asking you to do that in this question.)

3. **[10 points]** Explain the McKelvey Box. What are the implications of the McKelvey Box for the debate on resource scarcity?

4. **[6 points]** In some developing countries (and perhaps other countries as well), there is a connection between deforestation and each of the following. Explain each connection. (Another way of asking this question is: "Explain the connection between deforestation and each of the following phenomena.")

   (a) less clean drinking water

   (b) reduced hydroelectric generating capacity

   (c) decreased crop yields

   (d) reduced numbers of livestock

   (e) lower-quality human diets

   (f) increased frequency of attacks on women.

5. **[10 points]** Give a graphical explanation of the Coase Theorem.

6. **[9 points]** What is consequentialism and what does it have to do with this course?

7. **[10 points]** Herman Daly has written about the following ends-means spectrum:

   - Ultimate End
   - Intermediate End
   - Intermediate Means
   - Ultimate Means.

What do these terms mean?

What academic disciplines study the first and last components of this spectrum, and which academic disciplines study the connections between each of the components?

What is the relevance of all this for our course?

Answers to Final Exam, Econ. 5250, Fall 2017

1. (a) H_t is harvest at time t; X_t is stock size at time t. E is fishing "effort."

   The left-hand side is profit and the right-hand side is total revenue minus total cost, which is the definition of profit.

   Last term on right-hand side: Total cost TC depends on E. As E increases, total cost goes up. In turn, effort depends on H and X. With X constant, it takes more effort to harvest more fish, so $\partial E/\partial H > 0$. With H constant, $\partial E/\partial X < 0$ for a search fishery (as X goes up, it's easier to catch the fish, so effort falls), while for a schooling fishery, $\partial E/\partial X = 0$.

   First term on right-hand side: Total revenue TR is price times quantity sold. Quantity sold is H_t. Dependence on price is suppressed because the firm takes price as given, and in the steady state, the price (and all other variables) will be constant in time.

   Since the right-hand side ultimately depends only on H_t and X_t, that is what the left-hand side must depend on, too, which is why its Π is written as depending on H_t and X_t.

   (b) The rate of discount is δ. $\Pi_t/(1+\delta)^t$ is the present discounted value (sometimes just called "the present value") of Π_t discounted back to time zero dollars. The sum, $\sum_{t=0}^{\infty}$, applies discounting to the sequence of individual years' profits, $\{\Pi_0, \Pi_1, \Pi_2, \ldots\}$. The sum expands to

   $$\frac{\Pi_0}{(1+\delta)^0} + \frac{\Pi_1}{(1+\delta)^1} + \frac{\Pi_2}{(1+\delta)^2} + \cdots = \Pi_0 + \frac{\Pi_1}{1+\delta} + \frac{\Pi_2}{(1+\delta)^2} + \cdots .$$

   This is important because this is what a firm would want to maximize.

   (c) $X_{t+1} - X_t$, the stock size in year $t+1$ minus the stock size in period t, is the amount the stock size grew in period t. That is equal to "births minus natural deaths," which is $F(X_t)$, minus the additional deaths caused by humans, which is H_t.

   (d) The problem of a competitive net-present-value-maximizing private-property fishery is to maximize (2) given (3), where Π in (2) is defined by (1).

   (e) (2) is irrelevant for open-access fisheries because there is no "present versus future" tradeoff for firms in such an industry: if (economic) profit is strictly positive, new firms will enter the

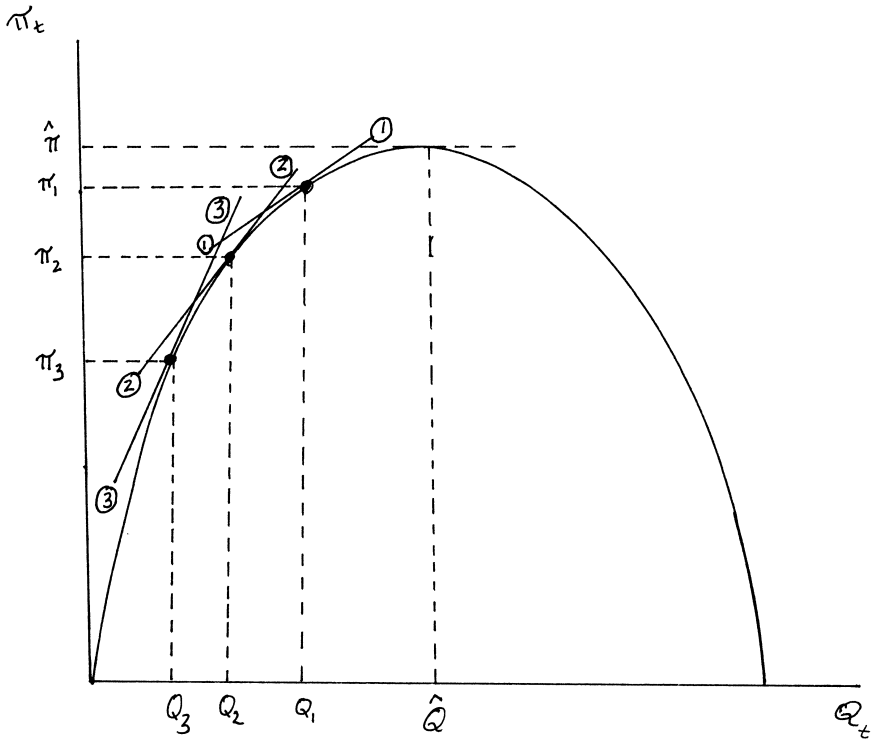

Figure 1

industry and compete away that profit. (They *can* enter due to the lack of property rights.) So in open-access, $\Pi = 0$ at all dates. For private-property fisheries, (2) is relevant and typically $\Pi_t > 0$.

(f) With an exhaustible resource, $F \equiv 0$ (no births nor natural deaths). The rest of the equations could be thought of as remaining the same. That gives rise to the Hotelling Rule, the most important result in neoclassical exhaustible resource economics.

2. (a) A typical graph of profit versus quantity is in Figure 1. This shape is typical of many industries, not just exhaustible resource. At $Q = 0$, there is no profit (a "long run" situation, with no fixed costs). Profit is rising for small Q, but after some point, called here $\hat{Q}$, profit is falling.

(b) At $\hat{Q}$. At this point, marginal profit (the slope of the tangent line) is zero.

(c) It would be at points such as (Q_1, π_1), then later at (Q_2, π_2), and even later at (Q_3, π_3). This is because the Hotelling Rule says marginal profit has to rise at the rate of interest, so the tangent lines—whose slope is marginal profit—have to get steeper. At

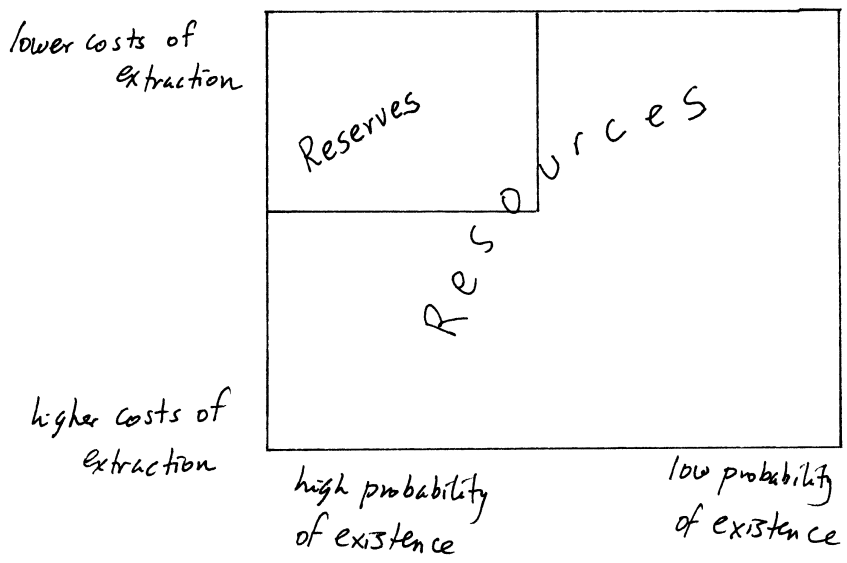

Figure 2

Q_1 the tangent line is ①-①, then Q_2 has a steeper tangent line of ②-②, and finally Q_3 has an even steeper tangent line of ③-③.

(d) Going from Q_1 to Q_2 to Q_3, profit goes from π_1 to π_2 to π_3, so total profit is falling with time. This makes sense because profit cannot be kept high (neither at $\hat{\pi}$ nor at π_1) forever because the resource is exhaustible and so Q has to eventually approach or reach zero. Because future profits are worth less than current profits due to discounting, it's optimal for the firm to get higher profits soon and lower profits later, rather than lower profits soon and higher profits later. (The word "optimal" in this context means present-discounted-value-maximizing.)

3. Your textbook has a detailed McKelvey Box (its Figure 19.1); a simplified version appears in Figure 2. The Box shows deposits of a resource as varying in their cost of extraction (vertical axis) and how probable it is that the resource exists (horizontal axis). ("Reserves" are in the upper left-hand part of the Box, with relatively low extraction costs and relatively high probability of existence.) The idea of this varied resource quality is emphasized by the "Ricardian" viewpoint on resource scarcity. This viewpoint is more optimistic than the Malthusian view, when tends to think of resources suddenly being all used up and disappearing. This viewpoint is less optimistic than the "Cornucopian" view, which holds that resource limitations (such as the fact that the McKelvey Box is finite in size) are not very important.

4. (a) Deforestation causes soil erosion, which causes dirt (soil) and debris to enter bodies of water, causing water pollution and salination.
   (b) Deforestation causes soil erosion, which causes dirt (soil) and debris to enter bodies of water, causing sedimentation and siltation of hydroelectric dams' reservoirs, reducing their capacity to store water.
   (c) Deforestation causes soil erosion, which causes reduced soil fertility.
   (d) Deforestation causes lack of firewood, so crop residues are diverted from fodder to be burned for fuel.
   (e) Deforestation causes lack of firewood, so less fuel is available for cooking, so less food which requires cooking can be eaten.
   (f) Particularly in Africa, fuelwood gathering is women's work. Deforestation causes women to have to travel farther from their homes in search of fuelwood. When the women live in refugee camps in violent regions, some are attacked when they leave the safety of the refugee camps. The more time they have to spend away from the camps, the more frequently they are attacked.
5. See the answer to part (a) of Question 1 of the Final Exam of Fall 2005.
6. See the answer to Fall 2006 Exam 1 Question 6.
7. See the answer to Fall 2006 Final Exam Question 8. "Narrow Economics" could be labeled "political economy."