Economics 5250/6250 | Dr. Lozada
Fall 2014 | Final Exam

This exam has 67 points. There are seven questions on the exam; you should work all of them. Each question 9 points each, except the first two questions, which are worth 11 points each.

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 questions.**

1. **[11 points]** In class we derived the following equation:

$$(1+\delta)M\Pi_7 = [1+F_8']\,M\Pi_8 + \frac{\partial \Pi_8}{\partial X_8}\,.$$

   (a) What does this equation simplify to in the steady state?

   (b) Give an intuitive explanation of "$\partial\Pi/\partial X = 0$."

   (c) Give an intuitive explanation of the equation you derived in part (a) if $\partial\Pi/\partial X = 0$. (You need not repeat what you said in part (b).)

2. **[9 points]** Contrast the Hotelling-Rule price path for a given exhaustible resource if the interest rate is:

   (a) high;

   (b) low.

   Explain your answer.

3. **[9 points]** According to "Hartwick's Rule" (not to be confused with "Hotelling's Rule"), development is sustainable if the total capital stock is kept constant.

   (a) What does this mean, given the importance of exhaustible resources?

   (b) Why do some people (not everyone!) argue that this is not a useful idea?

4. **[9 points]** This problem concerns the market for tradeable pollution permits.

   Draw a graph with "permit price" on the vertical axis and "permit quantity" on the horizontal axis.

   (a) What does this graph's supply curve look like? Why does it look this way?

   (b) What does this graph's demand curve look like? Why does it look this way? Be thorough in your explanation.

5. **[9 points]** Your book quotes a government commission as defining the "Best Practicable Environmental Option" ("BPEO") as

> ...the outcome of a systematic consultative and decision-making procedure which emphasizes the protection and conservation of the environment across land, air and water. The BPEO procedure establishes, for a given set of objectives, the option that provides the most benefit or least damage to the environment as a whole, at acceptable cost, in the long term as well as in the short term.

   Discuss this.

6. **[11 points]**
   (a) What is the present value of "−\$10 today and +\$12 in one year" if the discount rate is $\delta$?
   (b) Why might the firm be interested in knowing the answer to part (a)?
   (c) Suppose a firm is trying to evaluate the prospect of "−\$10 today and an uncertain amount in one year, with the expected payoff in one year being +\$12" if the discount rate is $\delta$. How might the firm do this by changing part (a)'s calculations? (Suppose the firm is risk-averse.)

7. **[9 points]**
   (a) Construct a consequentialist ("teleological") argument in favor of the following proposition: "we should adopt no policies to alleviate global climate change." Explain why this argument is consequentialist ("teleological").
   (b) Construct a non-consequentialist ("deontological") argument in favor of the following proposition: "we should adopt no policies to alleviate global climate change." Explain why the argument is non-consequentialist ("deontological").

   (This question requires you to be creative because we did not answer it in class.)

# Answers to Econ. 5250/6250 Final Exam, Fall 2014

① $(1+\delta) M\pi_7 = [1 + F'_8] M\pi_8 + \frac{\partial \pi_8}{\partial x_8}$

a) In the steady state, time subscripts are unimportant because all the variables are constant:

$$(1+\delta) M\pi = [1+F'] M\pi + \frac{\partial \pi}{\partial x}$$

$$M\pi + \delta M\pi = M\pi + F' M\pi + \frac{\partial \pi}{\partial x}$$

$$\delta M\pi = F' M\pi + \frac{\partial \pi}{\partial x}$$

$$\delta = F' + \frac{1}{M\pi} \frac{\partial \pi}{\partial x}$$

or $F'(x_{ss}) = \delta - \frac{1}{M\pi} \frac{\partial \pi}{\partial x}$.

↑ the steady-state value of stock size "x"

$\delta$ : discount rate

$\pi$ : profit

$M\pi$ : marginal profit

$F$ : excess of births over deaths; also written $F(x)$

$F'(x)$ : $dF/dx$ ; also written $F'$

b) $\pi$ = total revenue − total cost

= price × quantity sold − total cost

(quantity sold: harvest "H"; total cost: "TC")

over →

Neither price nor H depend on X, so

$$\frac{\partial \pi}{\partial X} = 0 - \frac{\partial TC}{\partial X} = - \frac{\partial TC}{\partial X}.$$

"search fishery" ⇒ (↓ in X ⇒ ↑ TC with given H because with less X, the fish are harder to find, increasing costs)

⇒ $\partial TC / \partial X < 0$.

"schooling fishery" ⇒ (↓ in X ⇒ no effect on TC given H because the schools of fish are easy to find even if there are few of them)

⇒ $\partial TC / \partial X = 0$.

c) In this case, $\delta = F'(X_{ss})$.

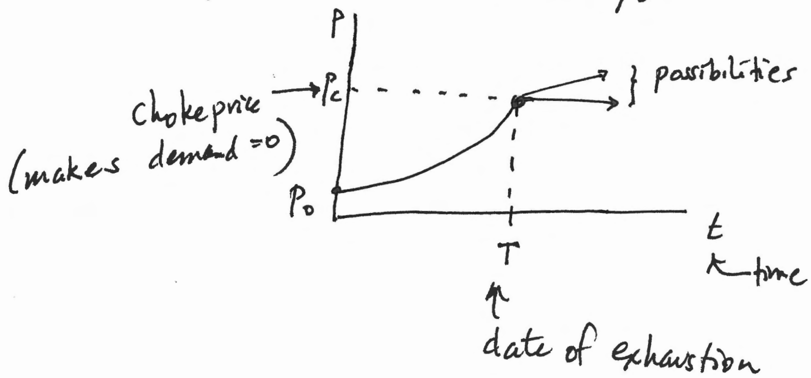
$\delta$: rate at which money in the bank grows

$F'(X_{ss})$: rate at which fish in the ocean grow

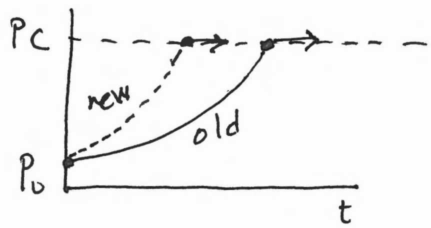
If $\delta > F'(x)$, discounted present value would be maximized by harvesting more fish to turn them into money (which grows at $\delta$). If $\delta < F'(x)$, fewer fish should be harvested, since a fish stock reproduces more quickly than money in a bank so you want more fish stock.

② (and perfect competition)

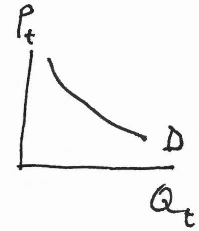
Assuming zero extraction costs for simplicity, the Hotelling-Rule price path is price rising at the rate of interest: $p_{t+1} = (1+\delta)\,p_t$. This is an exponential path, starting from some initial value $p_0$:




If $\delta$ were to increase to $\delta'$ without changing $p_0$, the new price path would be




(it grows more quickly since $\delta' > \delta$). But given a fixed demand curve

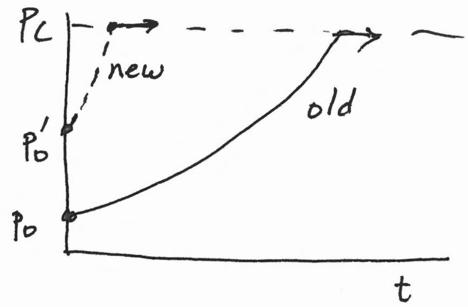



$p_t' > p_t$ for all t $\Rightarrow$ $q_t' < q_t$ for all t. Along the old path, we
(new price; new quantity; quantity: also written $Q_t$)

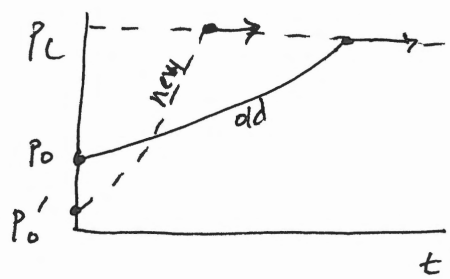
know that exhaustion occurred (it's not net-present-value maximizing to leave resource in the ground forever). Then "$q_t' < q_t$ for all t" means resource will be left in the ground forever under the new path, which can't be right.

Thus the "$p_0 = p_0'$" assumption must have been wrong. If $p_0' > p_0$

then




which makes the problem worse. So we need




So in the beginning $p_t' < p_t$ and at the end $p_t' > p_t$; thus in the beginning $q_t' > q_t$ and at the end $q_t' < q_t$,

so both quantity paths could result in complete exhaustion, as is optimal for the firms.

<u>Note</u>: One could also start by assuming $\delta' < \delta$. Then $p_0' = p_0$ would imply

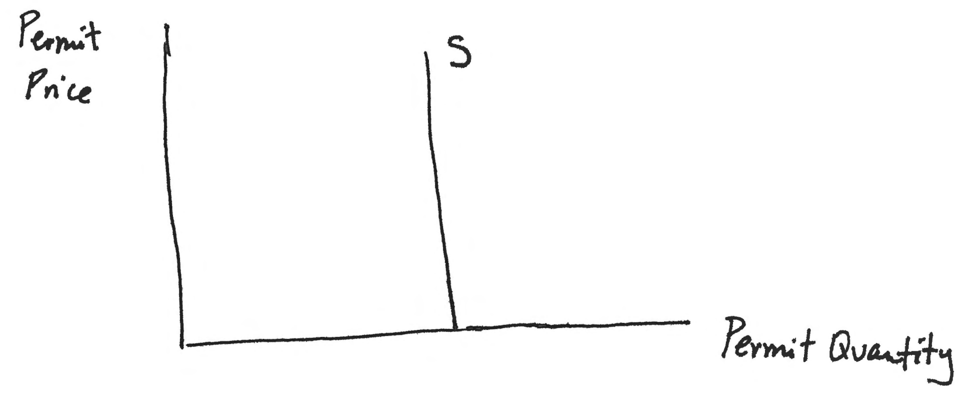

so $q_t' > q_t$ for all t (since $p_t' < p_t$ for all t); but "$q_t' > q_t$ for all t" is not feasible because exhaustion occurred along $q_t$. Taking $p_0' < p_0$ would make this worse, so we need $p_0' > p_0$.

③ a) The diminution of exhaustible resources is a fall in capital stock. Sustainability could only be achieved in the face of this fall if other components of capital rise sufficiently to offset the fall caused by resource exploitation.

b) Many of the "other" components of the capital stock are constructed using natural resources. It's not feasible to build up these components of the capital stock when natural resources are being exhausted. Hence this may be no solution to resource exhaustion. Even if it were possible to build up other aspects of the capital stock while natural resources (or just exhaustible resources) are declining, different types of capital goods may be imperfect substitutes for each other, making the notion of "the" capital stock problematic.

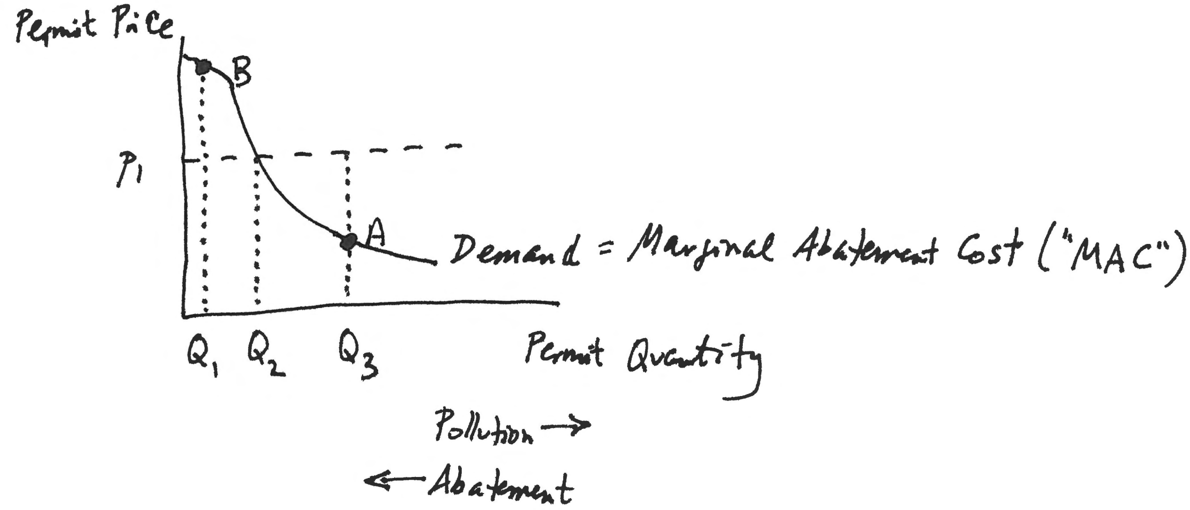
④

a)




The supply of permits is fixed by the government. One hopes it is fixed at the socially-optimal level of pollution.

b)




The demand curve for pollution permits is the MAC curve. To prove this, refer to the above diagram. The more permits a firm holds, the more it will pollute, so pollution increases to the right. The opposite of pollution is abatement, so abatement increases to the left. Our usual assumption is that as abatement increases, MAC rises because abatement becomes increasingly difficult. The MAC curve in the graph is drawn accordingly.

Suppose the permit price is $P_1$. A firm would not want to buy the $Q_3$ rd permit because it would cost $p_1$, whereas abating that unit of pollution instead only costs A, and $A < p_1$. A firm would want to buy the $Q_1$ st permit because it would only cost $p_1$, whereas abating that unit of pollution instead would cost B, and $B > p_1$. So permits would be bought up until MAC is not above $p_1$ any more, hence up until $Q_2$. In other words, if the permit price is $p_1$ then the permits bought will be $Q_2$. This proves that the MAC curve is the firm's "demand for permit" curve.

(5) This definition has vague and imprecise language in some places. For example:

1) "which emphasizes" : how much is environmental protection "emphasized" over other goals? What does this emphasis really mean? Does environmental protection get a 51% weight? A 100% weight?

2) "protection and conservation" : what is the difference between these two words? Presumably they are not synonyms, for if they were, one of them would be redundant. Yet it's not clear how they differ.

3) "across land, air and water." What if eliminating one such type of pollution – say, eliminating air pollution by banning incineration of garbage – causes more of one of the other types of pollution, such as land pollution?

4) "for a given set of objectives" : what are they, exactly?

5) "the environment as a whole" : how are different parts of the environment weighted to come up with an "as a whole" measure?

6) "at acceptable cost" : acceptable to whom? Industry? Environmental groups? Future generations?

over →

7) "in the long term as well as in the short term" : what if there is a conflict between short-term goals and long-term goals? For example, what's best for combatting global climate change in the long run is nonsense when only considering the short term.

Overall, this definition glosses over every facet of environmental decision-making which is difficult. It does so by denying that there are difficult trade-offs involved in most such decision-making.

(You can get full credit without a complete list of questionable phrases.)

⑥ a) present value $PV = -10 + \frac{12}{1+\delta}$

or, more explicitly, $PV = \frac{-10}{(1+\delta)^0} + \frac{+12}{(1+\delta)^1}$

since the contribution to PV of \$x, n years from now is $\frac{x}{(1+\delta)^n}$. For $\delta > 0$ (as usual), $\frac{x}{(1+\delta)^n} < x$, showing that \$x in the future is worth less than \$x today.

b) For example, the firm might want to know if investing \$10 now for a payoff of \$12 a year from now is a good idea or a bad idea, because if it is a good idea they will do it and if it is a bad idea they will not do it. (This assumes they have such a potential investment opportunity and no other.) A "good idea" here means $PV > 0$. At $\delta = 0$, $PV > 0$, but as $\delta$ increases, PV falls; $PV < 0$ if $\delta < \frac{12}{10} - 1 = 0.2$. optional

c) The expected PV is still $-10 + \frac{12}{1+\delta}$, but the risk-averse firm will fear that this is too optimistic because of the risk that the future payoff will be less than \$12. Such a firm might alter the PV formula to $-10 + \frac{\text{something less than \$12}}{1+\delta}$ (for example, $-10 + \frac{11}{1+\delta}$), but the more traditional approach is to change the PV formula to $-10 + \left[\frac{12}{1 + \text{something more than } \delta}\right]$.

This idea, using a higher $\delta$, also leads to a lower PV, making it less likely the risky project will be undertaken.

<u>Optional</u>: Suppose the future payoff is \$6 with probability $\frac{1}{2}$ and \$18 with probability $\frac{1}{2}$. The expected payoff is $\$6\left(\frac{1}{2}\right) + \$18\left(\frac{1}{2}\right) = \$3 + \$9 = \$12$, as

before. In class, I mentioned that a more straightforward way of valuing the risky outcome is to determine the utility to the decision-maker of

$$\begin{cases} -10 + \frac{6}{1+\delta} & \text{with probability } \frac{1}{2} \\ -10 + \frac{18}{1+\delta} & \text{with probability } \frac{1}{2}. \end{cases}$$

← optional →

One way of doing this — not the only way! — is to assert that this has the same utility as

$$\frac{1}{2}\,\text{utility}\left(-10 + \frac{6}{1+\delta} \text{ for sure}\right)$$

$$+ \frac{1}{2}\,\text{utility}\left(-10 + \frac{18}{1+\delta} \text{ for sure}\right).$$

This approach is called the "expected utility" approach. Risk aversion can be shown (in this context) to imply concave utility functions, so the value of the expected utility expression is less than $-10 + \frac{12}{1+\delta}$.

(7) a) consequentialist (teleological): acts are not good or bad in and of themselves, but should be judged good or bad depending on their consequences.

For example: "Global climate change is too expensive to fight. Fighting it generates benefits which are less than the cost of fighting it."

b) non-consequentialist (deontological): acts can be judged good or bad irrespective of their particular consequences in particular situations.

For example: "Each generation should depend only on itself, not on prior generations. So future generations should not depend upon us to sacrifice for them." *

Optional: This is the opposite of the non-consequentialist argument that we should adopt policies to alleviate global climate change because we have moral obligations to future generations.

* Another example: "Firms have the right to pollute. Making them curb pollution is illegitimate."