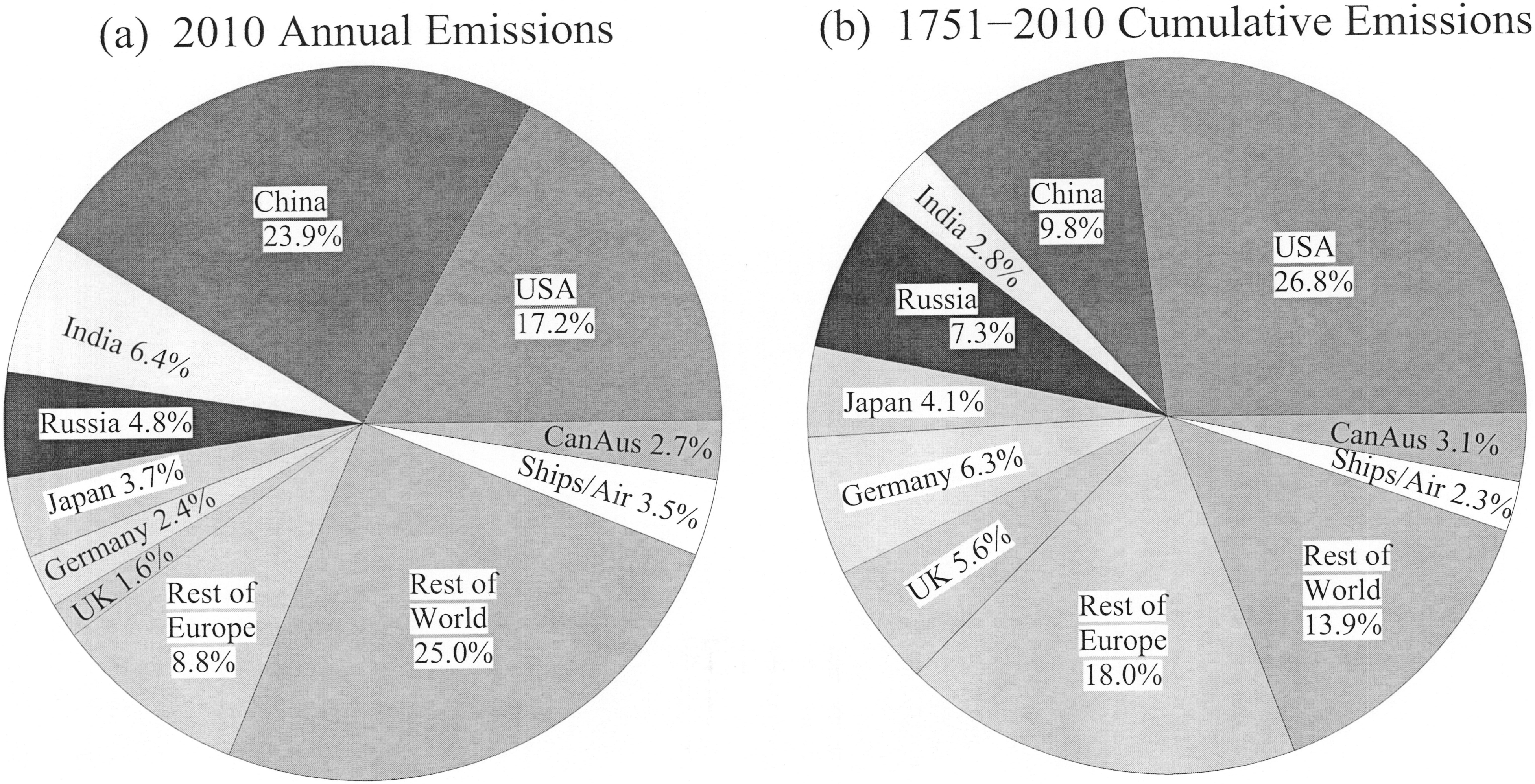
Economics 5250/6250 Dr. Lozada
Fall 2011 Final Exam

This exam has 67 points. There are seven questions on the exam; you should work all of them. The questions vary in how much they are worth from 7 points to 11 points each.

Put your answers to the exam in a blue book or on blank sheets of paper. The figure for the exam appears before the questions.

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.



(a) 2010 Annual Emissions

(b) 1751–2010 Cumulative Emissions

Fig. 1

**Answer all of the following questions.**

1. [**10 points**] On March 13, 2001, the office of the press secretary of then-President George W. Bush issued the text of a letter the president had written to several senators. It said in part:

   > As you know, I oppose the Kyoto Protocol *because it exempts 80 percent of the world, including major population centers such as China and India, from compliance*, and would cause serious harm to the U.S. economy. The Senate's vote, 95–0, shows that there is a clear consensus that the Kyoto Protocol is an *unfair* and ineffective means of addressing global climate change concerns. [emphasis added]

   Figure 1 shows greenhouse gas emissions. Explain how one half of Figure 1 can be used to support President Bush's argument that the Kyoto Protocol is unfair and how the other half of Figure 1 can be used to attack that argument. (The figure comes from `http://www.columbia.edu/~mhs119/Emissions/Emis_moreFigs` and shows carbon dioxide emissions.)

2. [**11 points**]

   (a) In class, I presented the following example:

   > Let $F(X)$ be the excess of births over natural deaths for a fish population, $X$ be the population size, $H$ be the harvest, and $E$ be fishing "effort." Suppose $F(X) = X(1-X)$ and $H = XE^{1/2}$. Find the steady-state relationship between $H$ and $E$.
   >
   > Answer: In the steady state, $F(X) = H$, so
   >
   > $$\begin{aligned} X(1-X) &= XE^{1/2} \\ 1-X &= E^{1/2} \\ X &= 1-E^{1/2} \end{aligned}$$
   >
   > and therefore $H = XE^{1/2} = (1-E^{1/2})E^{1/2} = E^{1/2} - E$.

   i. Why does this specification for $H$ (namely $H = XE^{1/2}$) make sense?

(b) Continue to assume that $H = XE^{1/2}$ (equivalently, $E = (H/X)^2$). Compare and contrast **THIS**

> "The profit of each firm is
>
> $$\mathit{\Pi}(H_t, X_t) = p_t H_t - c\,(H_t/X_t)^2 \tag{1}$$
>
> where $p_t$ is the price, and $c$ is the average cost, all at time $t$. The objective of the firm is to
>
> $$\max \sum_{t=0}^{\infty} \frac{\mathit{\Pi}_t}{(1+\delta)^t} \quad \text{s.t.} \tag{2}$$
>
> $$X_{t+1} - X_t = F(X_t) - H_t.\text{"} \tag{3}$$

with **THIS**

> "The profit of each firm is
>
> $$\mathit{\Pi}(E_t, X_t) = p_t X_t E_t^{1/2} - cE_t. \tag{4}$$
>
> The objective of the firm is to
>
> $$\max \sum_{t=0}^{\infty} \frac{\mathit{\Pi}_t}{(1+\delta)^t} \quad \text{s.t.} \tag{5}$$
>
> $$X_{t+1} - X_t = F(X_t) - X_t E_t^{1/2}.\text{"} \tag{6}$$

What economic situation or situations do (1)–(3) and (4)–(6) describe? Are (1)–(3) better, worse, or the same at describing this situation than (4)–(6)? What is the difference between the approach taken by (1)–(3), on the one hand, and (4)–(6), on the other hand?

3. **[10 points]** Sketch a graph of "price versus time" for an exhaustible resource industry obeying the Hotelling Rule. Then from your graph (together with other assumptions), derive a graph of "quantity versus time" for this industry.

4. **[7 points]** "Hartwick's Rule" states that the world economy can achieve sustainability if it keeps its total capital stock—which is the sum of its natural capital and its manmade capital—intact. Why might it be difficult to do this? Do you expect natural capital to rise or fall in the future? Why?

5. [**10 points**] Draw a graph, with appropriately labeled curves and axes, showing the nonoptimality of the free market in the presence of a *positive* externality.
6. [**9 points**] Discuss one difficulty with the travel cost method.
7. [**10 points**] What is the notion of “present discounted value” in economics? What role does it play in environmental and natural resource economics? Explain one aspect of it which generates controversy.

# Answers to Econ 5250 Final Exam, Fall 2011

① Part (a) of the figure, showing annual emissions, shows China with the highest level, the USA second, and India third. The Kyoto Protocol thus seems to be unfair, since it allows unrestricted emissions by China, India, and other developing countries. This supports President Bush's position.

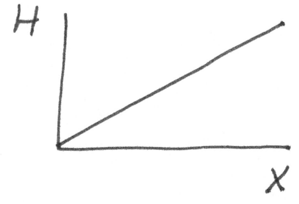
Part (b) of the figure shows 1751-2010 Cumulative Emissions. These are important for two reasons.

The first is that many of these past emissions are still in the atmosphere today, contributing (still) to the problem. So Part (b) shows better than Part (a) which nations have caused the current amount of greenhouse gases in the atmosphere to build up.

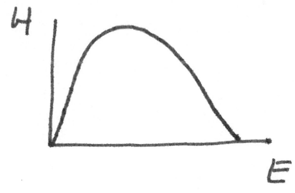
The second reason Part (b) is important is because some people say that what would be fair would be for each country to, over all time, emit the same amount of greenhouse gases per person.

For either (or both) of these reasons, Part (b) implies that the fair thing would be for the USA to be under much more stringent emissions standards than China, India, and other developing countries. This argues against President Bush's position.

② a) (i) Holding E constant, $H = X \cdot (\text{constant})$ :



More fish in the ocean (X) gives rise to more harvest (H) holding effort (E) constant. In class, we assumed this was linear.

(ii) This looks roughly like 

.

An increase in effort increases steady-state harvest to some extent; after all, zero effort would result in zero harvest, so some increase in harvest makes sense in response to effort increasing from zero. However, since this graph is of the steady state, beyond some point, ↑E ⇒ ↓H : more effort puts more stress on the fish stock, and in order to maintain that stock, H has to fall. On this part of the graph, more input (E) leads to less output (H) in the steady state.

b) Equation (1) is $\pi = p_t H_t - c(H_t/X_t)^2$. Substituting $H = X E^{1/2}$ (which means $H/X = E^{1/2}$) yields

$$\pi = p_t X_t E_t^{1/2} - c E_t$$

which is equation (4). Similarly, (3) and (6) are the same when $H = X E^{1/2}$. Equations (2) and (5) are always identical. So, when $H = X E^{1/2}$, (1)-(3) is the same as (4)-(6).

They give the net-present-value-maximizing problem of a privately-owned fishery.

(1)-(3) describe this problem using Harvest ($H$) and stock size ($X$) but not effort ($E$). (4)-(6) describes it using $X$ and $E$ but not $H$.

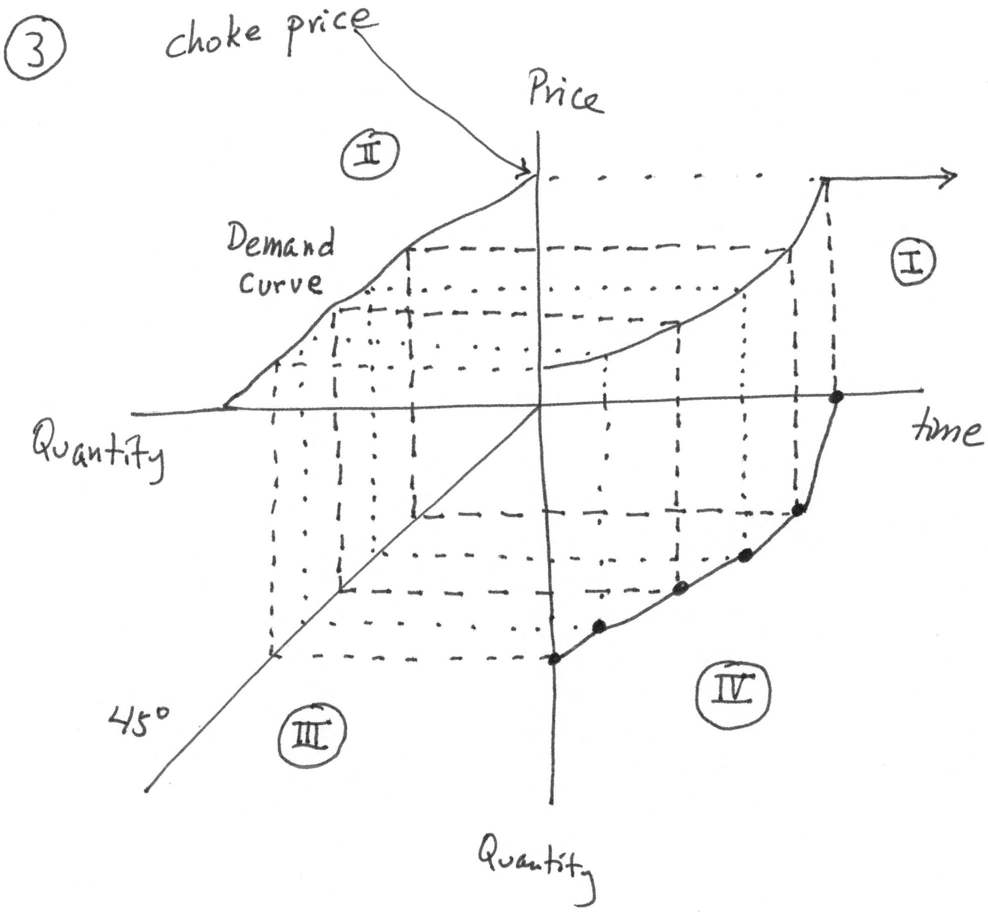
Descriptions of open-access fisheries often use $E$, so it would be easier to compare open-access and private-property fisheries using (4)-(6) than (1)-(3).

Optional: One could eliminate $X$ and only use $H$ and $E$, as in

$\pi = p_t H_t - c E_t$ such that

$$\frac{H_{t+1}}{E_{t+1}^{1/2}} - \frac{H_t}{E_t^{1/2}} = F\left(\frac{H_t}{E_t^{1/2}}\right) - H_t .$$

③

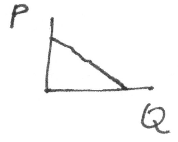


Quadrant I shows a price path that obeys the Hotelling Rule, which in general is

$$M\Pi_{t+1} = (1+\underset{\overset{\uparrow}{\text{interest rate}}}{\delta})\,\underbrace{M\Pi_t}_{\text{marginal profit}}$$

but can be simplified to

$P_{t+1} = (1+\delta) P_t$ (an exponential price path) if costs are zero and the firm is competitive (so that $M\Pi = MR - MC = MR = P$).

Quadrant II shows a market demand curve  with its horizontal axis flipped.

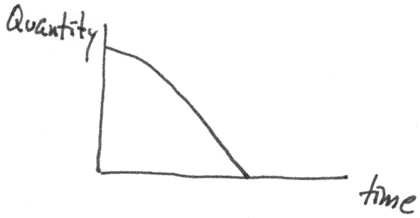
Quadrant III is a 45° line.

Quadrant IV is the answer to the question. It is generated by starting at a time point and going :

- $\underbrace{\text{up to Quadrant I}}_{\text{the price path in}}$, over to the demand curve of Quadrant II,

  down to the 45° line of Quadrant III, then to Quadrant IV ; and
- down to Quadrant IV .

Quadrant IV looks like this if the vertical axis is redrawn in the usual way :



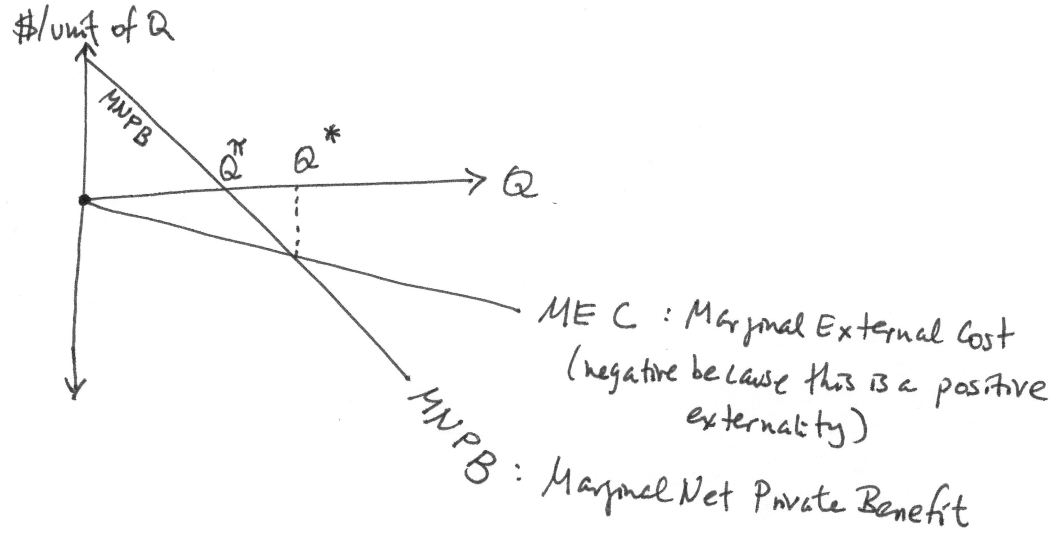
Note that at the date when quantity falls to zero, price reaches the choke price : in other words, when quantity supplied becomes zero, price is such that quantity demanded is zero too.

Natural capital includes renewable and nonrenewable natural resources. Nonrenewable natural resources shrink with time. So the only way natural capital could increase would be for renewable natural resources to increase. This means an increase of, for example, fish stocks or forests. In the past, such resources have usually shrunk instead of increased.* Other forms of natural capital include unpolluted oceans and air. At least with respect to some pollutants, the oceans and air are becoming dirtier.

If "manmade" capital requires natural capital, then the former cannot grow if the latter is used up. This would make sustainability hard or impossible to achieve, since the main way to compensate for the loss of nonrenewable resources would have to be an increase in manmade capital.

* And nature imposes limits on renewable resources (e.g. carrying capacities).

⑤



$Q^*$ : socially optimal level of output "Q"

$Q^\pi$ : level of output chosen by a private firm (where MNPB = 0)

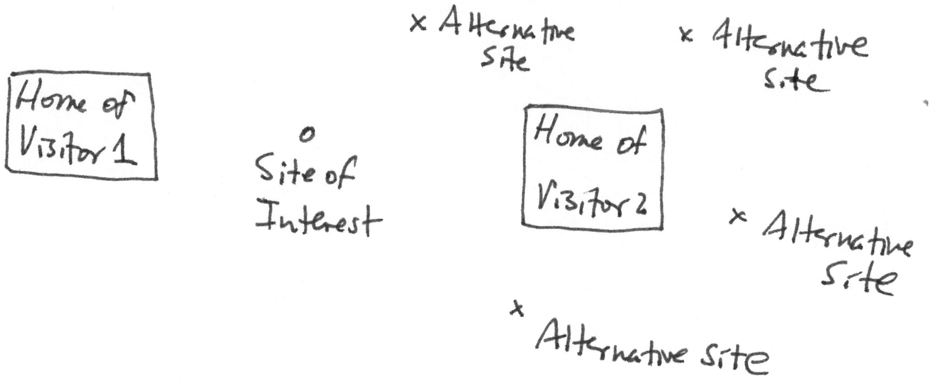
In this graph, $Q^\pi < Q^*$ : the free market generates a Q which is too small because the firm isn't paid anything for the positive externality it is generating.

⑥ One of:

i) It's hard to know how to value the time spent traveling (some people like the journey, others don't). (Forgone wages might be hard to obtain as well.)

ii) A journey might include more than one destination, in which case it's hard to apportion costs among the different destinations.

iii)



In this figure, both visitors incur the *same* travel cost to visit the site of interest. However, Visitor 2 might like it *more* than Visitor 1: Visitor 2 has many alternative sites to visit, but he instead went to the Site of Interest, so he must like it a lot; whereas Visitor 1 had no other interesting place to go, and merely considers the Site of Interest "better than nothing."

iv) Visitors who like a site so much that they choose to move nearby will have low travel costs but high site valuation.

⑦

The "present discounted value" of $\$x$ which is received $n$ years from now is $\frac{x}{(1+\delta)^n}$ where $\delta$ is the rate of interest or the rate of discount. "$x$" may be negative.

Economists (and private firm managers) need to use Present Discounted Value ("PDV") whenever they project that dollar flows eminating from one of their decisions will occur at different times. For example, PDV analysis underlies private property fishery analysis and the Hotelling Rule.

Picking what $\delta$ (interest rate or discount rate) to use is often controversial. For a policy issue like global warming, with costs soon and benefits far into the future, the higher the choice of $\delta$, the less the PDV of benefits from limiting the pollution soon, while $\delta$ wouldn't affect the PDV of the costs much because they accrue soon. So a higher $\delta$ leads to less desirability to fight global warming.