Economics 5250/6250 Dr. Lozada
Fall 2016 Final Exam

This exam has 67 points. There are seven questions on the exam; you should work all of them. The questions are worth either 9 or 10 points each. You have two hours to complete this test.

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.

For the question involving a graph, you may either draw on the original figure, then remove it from the exam and include it with your answers; or you may redraw the figure on your answer sheet. If you choose the first option, write your first name on each page (to prevent confusion if the page gets separated from the rest of your exam).

Answer all of the following seven questions.

1. **[9 points]** The Second Law of Thermodynamics says that in an isolated system, entropy increases (or stays constant).

   Some people have interpreted entropy as a measure of "disorder." The word "disorder" here can be thought of as some type of index of how mixed-up or jumbled-up things are.

   Use the following two examples to argue that entropy should *not* be thought of as a measure of disorder, where the word "disorder" has the meaning given in the previous paragraph. You can think of the two examples as being isolated systems.

   (a) Putting a drop of ink into a glass of water.

   (b) Putting a drop of oil into a glass of water.

2. **[10 points]** Look at Figure 1, which is one page of a class handout. Write down the mathematical formulation of the problem for which this is the answer. Also give the economic interpretation of that formulation.

3. **[10 points]** This question concerns open access.

   (a) Briefly explain Figure 2a. [It appears later in this exam; please look for it.] You do not need to derive it.

   (b) Sketch the supply curve of the firm if the following describe its situation:

      i. Figure 2b.

      ii. Figure 2c.

      iii. Figure 2d.

      Remember to explain your answers.

   (c) Do you think the open-access supply curve can be upward-sloping for all levels of price, regardless of how large?

4. **[10 points]** Graphically show the amount of Net Private Benefit lost by a firm upon whom is imposed an optimal Pigouvian tax. (Note that this question is not asking about Marginal Net Private Benefit, and least not directly.) Explain your answer thoroughly.

so

$$0 = \frac{\partial \Pi_8}{\partial X_8} - (1+\delta)\frac{\partial \Pi_7}{\partial H_7} + \big[1 + F'(X_8)\big]\,\frac{\partial \Pi_8}{\partial H_8}. \tag{9}$$

From (1), $\Pi_8 = TR_8(H_8) - TC(H_8, X_8)$, so $\frac{\partial \Pi_8}{\partial X_8} = -\frac{\partial\, TC}{\partial X_8}$; call this $-C_{X8}$ for short. By definition, $\frac{\partial \Pi_7}{\partial H_7} = M\Pi_7$ and $\frac{\partial \Pi_8}{\partial H_8} = M\Pi_8$. Also, let $F'(X_8)$ be abbreviated by F_8'. Then substituting these results into (9) yields

$$0 = -C_{X8} - (1+\delta)M\Pi_7 + [1 + F_8']\,M\Pi_8 \tag{10}$$

which can be rewritten as

$$(1+\delta)M\Pi_7 = [1 + F_8']\,M\Pi_8 - C_{X8} \tag{11}$$

or as

$$(1+\delta)M\Pi_7 = [1 + F_8']\,M\Pi_8 + \frac{\partial \Pi_8}{\partial X_8}. \tag{12}$$

If, in (12), there is a steady state, then this equation becomes

$$(1+\delta)M\Pi = [1 + F']\,M\Pi + \frac{\partial \Pi}{\partial X}\,, \tag{13}$$

which simplifies to

$$\delta\, M\Pi = F'\,M\Pi + \frac{\partial \Pi}{\partial X} \tag{14}$$

or

$$\delta = F' + \frac{1}{M\Pi}\frac{\partial \Pi}{\partial X}\,. \tag{15}$$

Finally, to show that this is consistent with what your textbook has, recall that by definition, $C_X = \partial\, TC/\partial X$. Your book, in (16.13), assumes that $TC = c(X)H$. (Your book uses C instead of c, but I think c is less confusing.) Maintaining this assumption, $C_X = \partial\big(c(x)H\big)/\partial X = c'(X)H$. In a steady state, $X_{t+1} = X_t$, so from (3), in a steady state, $F(X) = H$. Making this substitution results in

$$C_X = c'(X)F(x)\,. \tag{16}$$

In addition, in your book, equation (16.13) has $\pi = PH - c(X)H$, so

$$M\Pi = \frac{\partial \pi}{\partial H} = P - c(X)\,. \tag{17}$$

Substitute (16) and (17) into (15), remembering that $\partial\Pi/\partial X = -C_X$:

$$\delta = F' + \frac{-c'(X)F(X)}{P - c(X)}\,. \tag{18}$$

This is (16.16) of your textbook.

Figure 1

5. **[9 points]**

   (a) Which level of government regulates pollution in states of the USA? For example, is air pollution in Utah regulated by the State of Utah or by the federal government, or both? Be specific. Distinguish between "attainment" and "non-attainment" areas.

   (b) The US Clean Air Act imposes different restrictions on "new" versus "old" industrial facilities. What was the reason for this? What disputes have been caused by this feature of the Clean Air Act?

6. **[10 points]** Contrast utilitarian, contractarian, and libertarian notions of justice.

7. **[9 points]** Read the article below, which is from an online web site, `vox.com`. Then **explain how it could be used as an example to argue *against* the following position: "People are rational. They know best how to achieve the goals and wishes they have in life."** (You may think it is not a good example to use to argue against that position, but do so anyway.)

   > *Santa Monica is creating a low-carbon city only rich people can enjoy: Without density, urban "greening" is mostly symbolic.* By David Roberts, November 8, 2016.
   >
   > The world is rapidly urbanizing. It follows that a key part of tackling climate change is figuring out how to decarbonize cities. And all the evidence points to the conclusion that density—reducing the distances city dwellers need to travel and the shared energy and infrastructure needed to serve their needs—is a necessary prerequisite to serious decarbonization. . . .
   >
   > If you want to tackle climate change, you need to support densification.
   >
   > But in many growing urban areas, residents (mostly older, wealthier, whiter residents) are working hard to slow and block densification. They are doing so even as they celebrate their own eco-friendliness with back yard chicken coops, rooftop solar panels, and. . . canvas tote bags.
   >
   > The cognitive dissonance is reaching absurd levels.
   >
   > *Santa Monica ponders absurd new barriers to development*
   >
   > Take Santa Monica, California, population 92,000 or so.
   >
   > It's a really nice place. The weather is phenomenal. It's on the beach. It has ready access to the vast human and natural resources of the LA basin. Jobs are growing faster than the national average.

In addition to its other virtues, the city has always prided itself on its environmental awareness. Most recently, the city council took the extraordinary step of requiring that, as of 2017, all new single-family homes in the city be zero-net energy (ZNE), which means they must produce more power than they consume. Santa Monica is the first city in California to take this step.

Thanks to its many advantages, lots of people want to live and work in Santa Monica. But Santa Monicans are not super-jazzed about sharing.

Today, residents will vote on Measure LV—"Land Use Voter Empowerment," or LUVE—which would require that all new buildings above two stories (or 32 feet) be specifically approved by voters.

Yes, you heard that right: If this measure is passed, the residents of Santa Monica will have to vote on every proposed building above two stories.

The city council commissioned an expert assessment of the proposal. The analysis concluded that, yes, it's just as crazy as it sounds. It would exacerbate the problems it is trying to solve (traffic, gentrification), reduce the amount of affordable housing. . .

What's more, as longtime city planning activist Frank Gruber explains, Santa Monica isn't experiencing anything like the kind of headlong growth that would warrant such an extreme response. . . .

LUVE is being pushed by a group of residents called. . . the Residocracy. . . .

Earlier this year, Residocracy. . . opposed a seven-story, mixed-use development to be built near transit—the very model of sustainable urbanism. "We don't need additional housing," said Residocracy founder Armen Melkonians at a city council meeting, in defiance of both data and reason.

These battles over development in Santa Monica go way back. A few years ago, wealthy residents in the Wilmont Neighborhood Coalition voted for a moratorium on all new development in Santa Monica. They want to pull up the drawbridge behind them.

It's the same story as numerous other growing West-Coast cities: There are residents wealthy or lucky enough to own land/homes in the city; the land/homes are rapidly accruing value; that value depends in part on the scarcity of land/homes; thus, they would prefer to keep new land for development and new housing scarce.

I won't settle that endless debate here. I just want to look at it through the lens of carbon emissions—something Santa Monicans, for all their good climate intentions, don't seem to be doing.

Cities like Santa Monica need low-carbon systems, not low-carbon houses

The residents of Santa Monica enjoy a median income just shy of double the American average. Roughly 38 percent of them make more than $100,000 a year, compared to 22 percent of Americans at large.

Now imagine that LUVE passes. Picture a Santa Monica where new development has been choked off, leading property values to skyrocket further. All but the wealthiest will be priced out of housing. (Even more so than now, I mean.)

The wealthy of Santa Monica, by living in a place with strong environmental laws and standards, will avail themselves of a low-carbon lifestyle. They will live in low-carbon houses, drive low-carbon cars, and patronize low-carbon local businesses. The per-capita carbon emissions of those lucky residents will be low compared to others in their socioeconomic cohort.

But as job growth continues, people will keep coming to the city. That's part of what keeps a city vital—people keep coming. If those people can't afford a place to live in the city, they will be pushed to the periphery and beyond, to sprawling suburbs.

They will still drive into the city to work (that's why suppressing housing development only increases traffic). But they will live remotely, which means infrastructure will have to be built out to support them—roads, sewers, power lines. Delivery of all services will be more carbon intensive because people will be more spread out.

And those working class people on the periphery will likely be unable to afford ZNE houses or electric cars, so they will not enjoy the low-carbon lifestyle purchased by the wealthy of Santa Monica proper.

The choices of Santa Monica residents will have reduced their own carbon emissions, but they will have increased net carbon emissions. They will have approached climate change from the perspective of personal virtue, not of systems change.

But climate change is just a numbers game. Personal virtue doesn't count for much. The imperative is to build low-carbon systems, not individual low-carbon houses, and to get as many people as possible into those systems.

A building is a system. A neighborhood is a system. A community is a system. Part of making those nested and overlapping systems low-carbon is maximizing the number of people within them, minimizing the distances they have to travel, and providing them services with the minimum amount of energy and infrastructure.

If Santa Monica succeeds in setting up systems that enable a low-carbon lifestyle, by far the best thing it can do for the climate is to pack more people into Santa Monica.

Whereas if residents vote today at the polls to keep out newcomers, they will be doing a great disservice to the climate, no matter how many solar panels adorn their giant houses. [http://www.vox.com/science-and-health/2016/11/8/13556836/santa-monica-density-inequality]

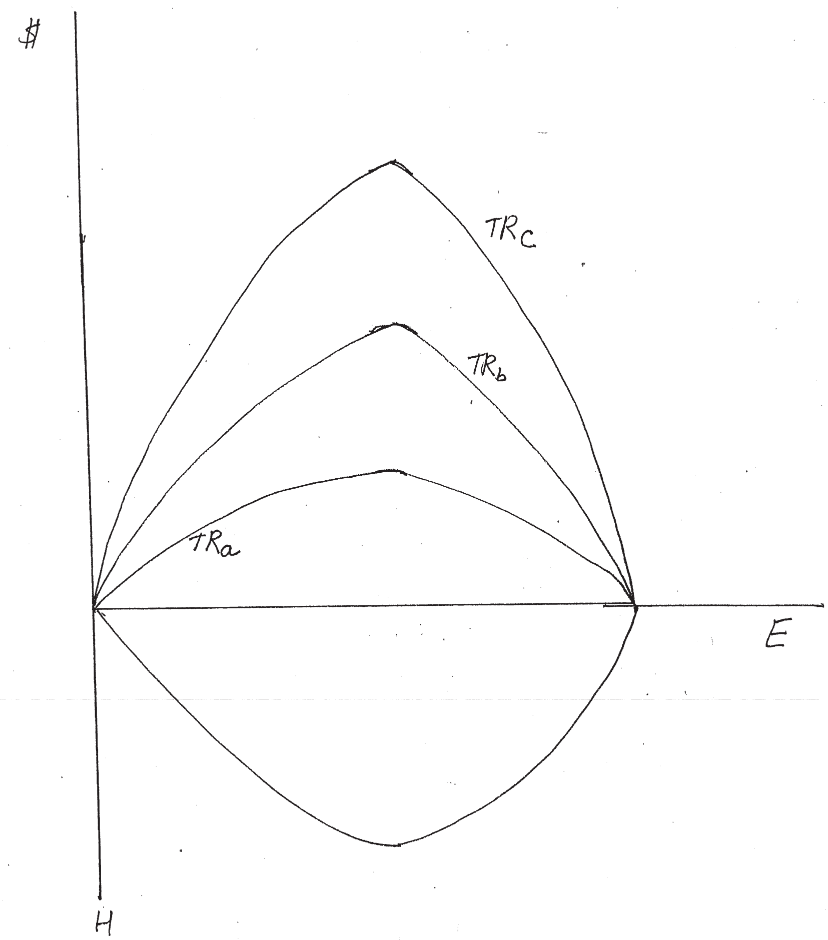


Fig. 2a

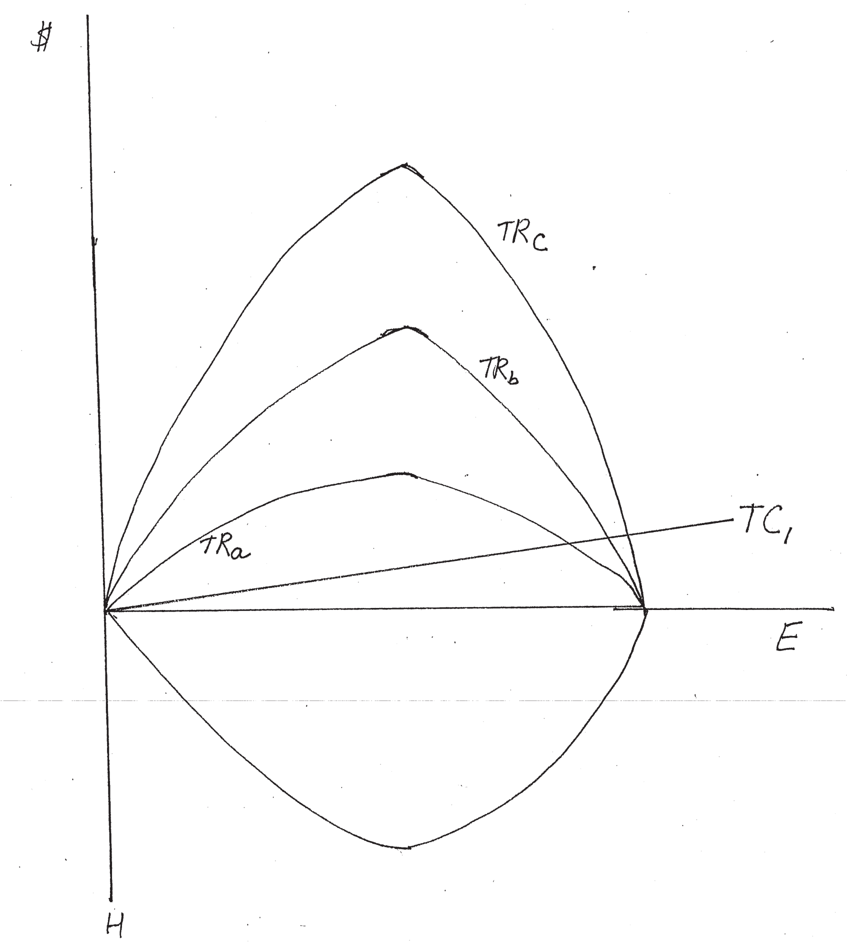


Fig.2b

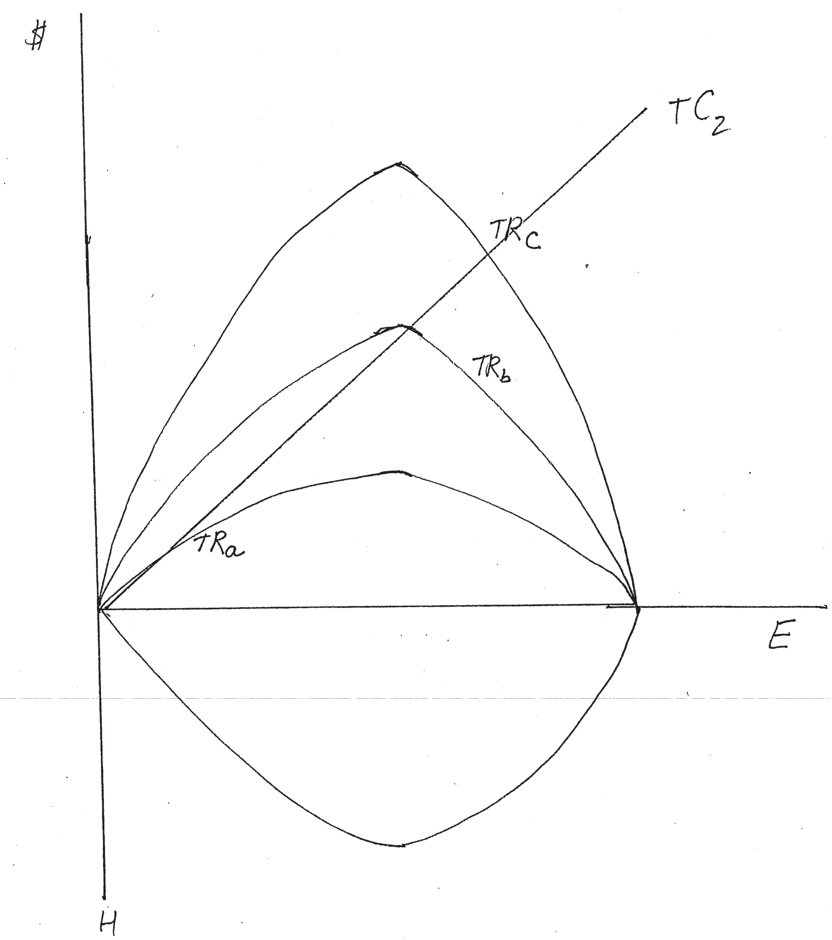


Fig. 2 c

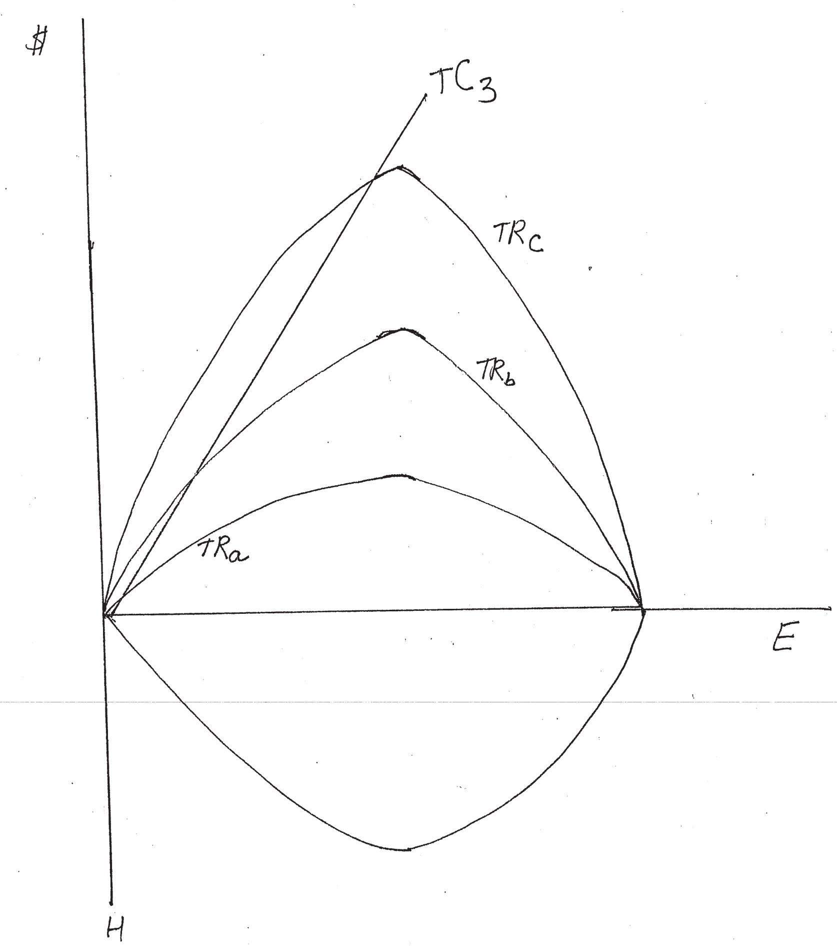


Fig. 2d

Answers to Final Exam, Econ. 5250/6250, Fall 2016

(Questions repeated from past years are usually not answered here if they were answered then.)

1. Whoever has interpreted entropy as a measure of disorder must be thinking that there is more to entropy change than is captured in the formula $\Delta S = H/T$ (ΔS is the entropy change, H is the heat flow, and T is the Kelvin temperature). So let's ignore the definition $\Delta S = H/T$ and see if "entropy as disorder" makes sense.

   In situation (a), as time goes on, the ink disperses in the water. (Ignore the fact that some rare types of ink might sink to the bottom of the container, like paint might.) Eventually, the ink is completely "mixed up" with the water. So as time goes on, "mixed-up-ness" increases. The Second Law of Thermodynamics says that in an isolated system, as time goes on, entropy increases (or stays constant). So this example would be consistent with the interpretation of entropy as a measure of disorder.

   In situation (b), however, as time goes on, the oil does not disperse in the water. (Ignore the possibility of an emulsion.) Indeed if, at the beginning, the container had been shaken, so that the oil was dispersed in the water, eventually the oil would group together with itself at the top of the water. So as time goes on, "mixed-up-ness" decreases. The Second Law of Thermodynamics says that in an isolated system, as time goes on, entropy increases (or stays constant). So this example would be completely inconsistent with the interpretation of entropy as a measure of disorder.

   Situation (b) serves as a counterexample to the idea that entropy is a measure of disorder, in any intuitive, everyday meaning of the word "disorder."

   Note 1: Using an intuitive idea of disorder, someone might argue that in situation (a), after the ink is completely dispersed, because the mixture is uniform, is would then be "orderly," not "disorderly." If one argued that way, then even the first example would contradict the interpretation of entropy as a measure of disorder. This ambiguity in how to describe the final state in situation (a) shows that a clearer definition of "disorder" would be necessary if "disorder" were to be the basis on interpreting entropy.

   Note 2: Using an intuitive idea of disorder, someone else might argue that in situation (a), because one knows for sure what is going to happen, the process would be "orderly," not "random" or "disorderly."

If one argued that way, then even the first example would contradict the interpretation of entropy as a measure of disorder. Again, this ambiguity in how to describe the final state in situation (a) shows that a clearer definition of "disorder" would be necessary if "disorder" were to be the basis on interpreting entropy.

Note 3: People who think that entropy is a measure of disorder aren't crazy, just wrong. Entropy change is, technically, not "$\Delta H/T$" but rather "$\Delta H/T$ during a 'reversible' process." The mixing of ink and water described above is not a reversible process, so its entropy change is not $\Delta H/T = 0/T = 0$. Instead, its entropy change would have to be calculated by moving from the initial state (the ink has just been dropped into the water) to the final state (the ink is uniformly mixed) in some other way than just letting the ink disperse: perhaps by moving a semipermeable membrane. Moving such a membrane takes work, and work and heat are aspects of the same thing (both are measured in Joules), and it turns out that during this second process of getting the system from its initial state to its final state (this time reversibly), heat does flow. Hence it turns out that there is an entropy difference between the initial and final states, even if one uses $\Delta H/T$ as one's definition of entropy. The problem comes in when people interpret this example to imply that entropy is more than merely $\Delta H/T$, but is instead some measure of mixing; and that that mixing means disorder or randomness.

2. Fall 2009 Final, qu. 2, with a part added.

   The problem is to maximize the present discounted value of profit,

$$\max \sum_{t=0}^{\infty} \frac{\pi_t}{(1+\delta)^t} = \pi_0 + \frac{\pi_1}{1+\delta} + \frac{\pi_2}{(1+\delta)^2} + \cdots$$

   (where π_t is the profit at time t,

$$\pi_t = TR(H_t) - TC(H_t, X_t),$$

   that is, total revenue minus total cost, and δ is the firm's rate of time discount), such that

$$X_{t+1} - X_t = F(X_t) - H_t$$

   where X_t is the fish stock size at time t, H_t is the fish harvest at time t, $X_{t+1} - X_t$ is the change in the number of fish over the course of year t, $F(X_t)$ is "births minus natural deaths," and the right-hand side represents "births minus natural deaths minus extra deaths caused by humans."

   Total revenue only depends on harvest,[1] not on the number of fish in the ocean, X. Total cost depends on harvest and, because of the "stock effect," on stock size, where the "stock effect" describes the increase in fishing costs arising from a decline in stock size in a search fishery. Biological reproduction of this species is described by $F(X_t)$.

   This describes the situation of a private-property fishery. *Optional:* By contrast, if the fishery is open-access, next year's fish stock X_{t+1} depends not only on one firm's H_t but on the harvest of all the other firms, and the problem becomes quite different (and actually does not involve trade-offs in time any more).

[1] *Optional:* Total revenue also depends on price, which is not mentioned because it is assumed constant in this model. Hence this is not an equilibrium model, where there is a downward-sloping demand curve, and where quantity demanded equals quantity supplied in every period. Constructing an equilibrium model is harder, and does not change the steady-state conclusion we came to, which has to be true for whatever the steady-state price happens to be.

3. Fall 2008 final, qu. 8, with one clarification.

   (a) The "*TR*" curves represent steady-state total revenue in an open access fishery, as function of effort "*E*." Prices is assumed to be constant along each of these curves. Price is lowest for the lowest *TR* curve, TR_a, and price is highest for the highest *TR* curve, TR_c.

   The upside-down curve in Quadrant IV represents steady-state harvest "*H*" as a function of effort. It shows that more effort does not necessarily lead to a rise in steady-state harvest.

   (b) The "*TC*" curves represent total fishing cost. As effort increases, total costs go up.

   In open-access steady-state equilibrium, total revenue equals total cost, so ("economic") profit is zero. (If it weren't, it wouldn't be a steady state: firms would either want to enter or exit.)

   As shown in the accompanying diagrams, setting $TC = TR$ determines effort, which in turn, through the graph in Quadrant IV, determines steady-state harvest. Combining the information for prices and steady-state harvests results in the supply curves shown on those pages. For Fig. 2b, supply is downward-sloping; for Fig. 2c, supply is backward-bending (so it has a positively-sloping part and a negatively-sloped part); and for Fig. 2c, supply is upward-sloping. Upward-sloping supply curves are typical in most other parts of economics.

   (c) No. As shown in the second attached version of Fig. 2d, ever-higher levels of price will generate ever-higher *TR* curves, so that eventually, *TC* will intersect some of the *TR* curves to the right of the maximum of each *TR* curve. That eventually generates geometry like that of Fig. 2b, with the supply curve eventually having a negative slope (higher price corresponding to lower harvest).

   Note: An incorrect reason why one might think that the supply curve cannot be upward-sloping for all levels of price is that there is a maximum steady-state harvest. However, that maximum harvest could be reached asymptotically as price goes to infinity, generating an always-upward-sloping supply curve. So the existence of a maximum level of steady-state harvest is no guarantee that the supply-curve is not always upward-sloping.

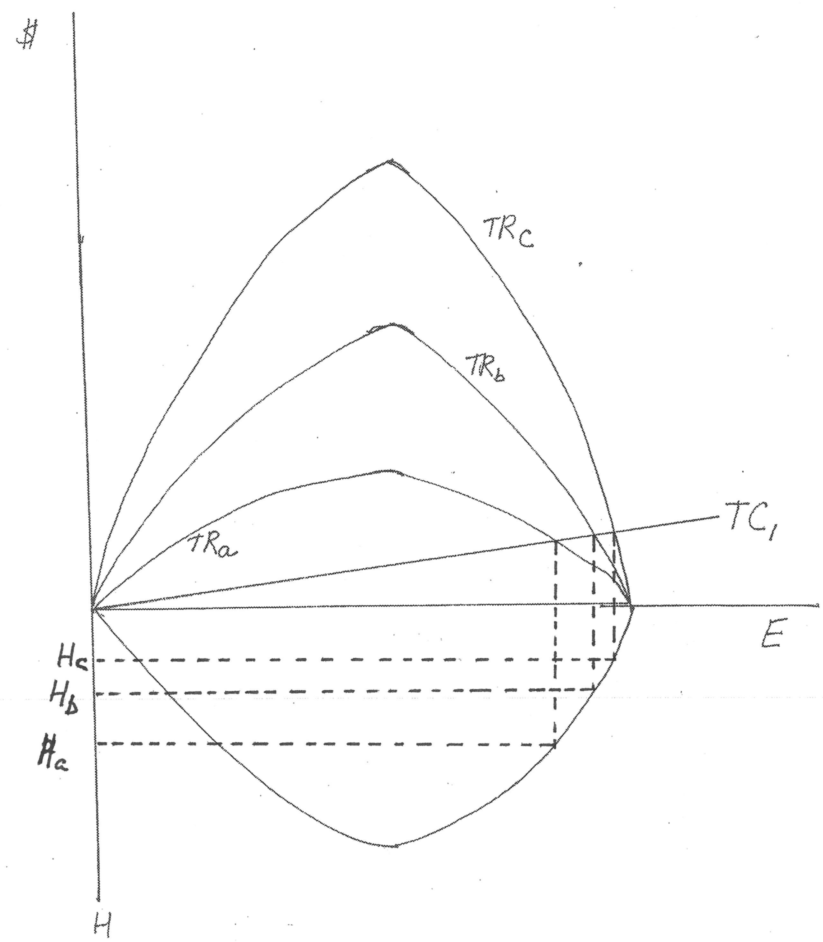
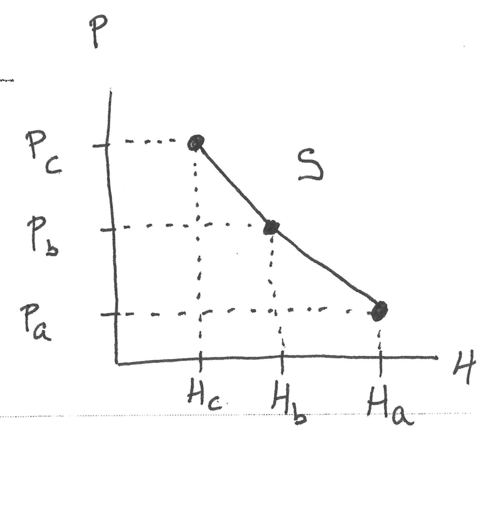


Fig.2b



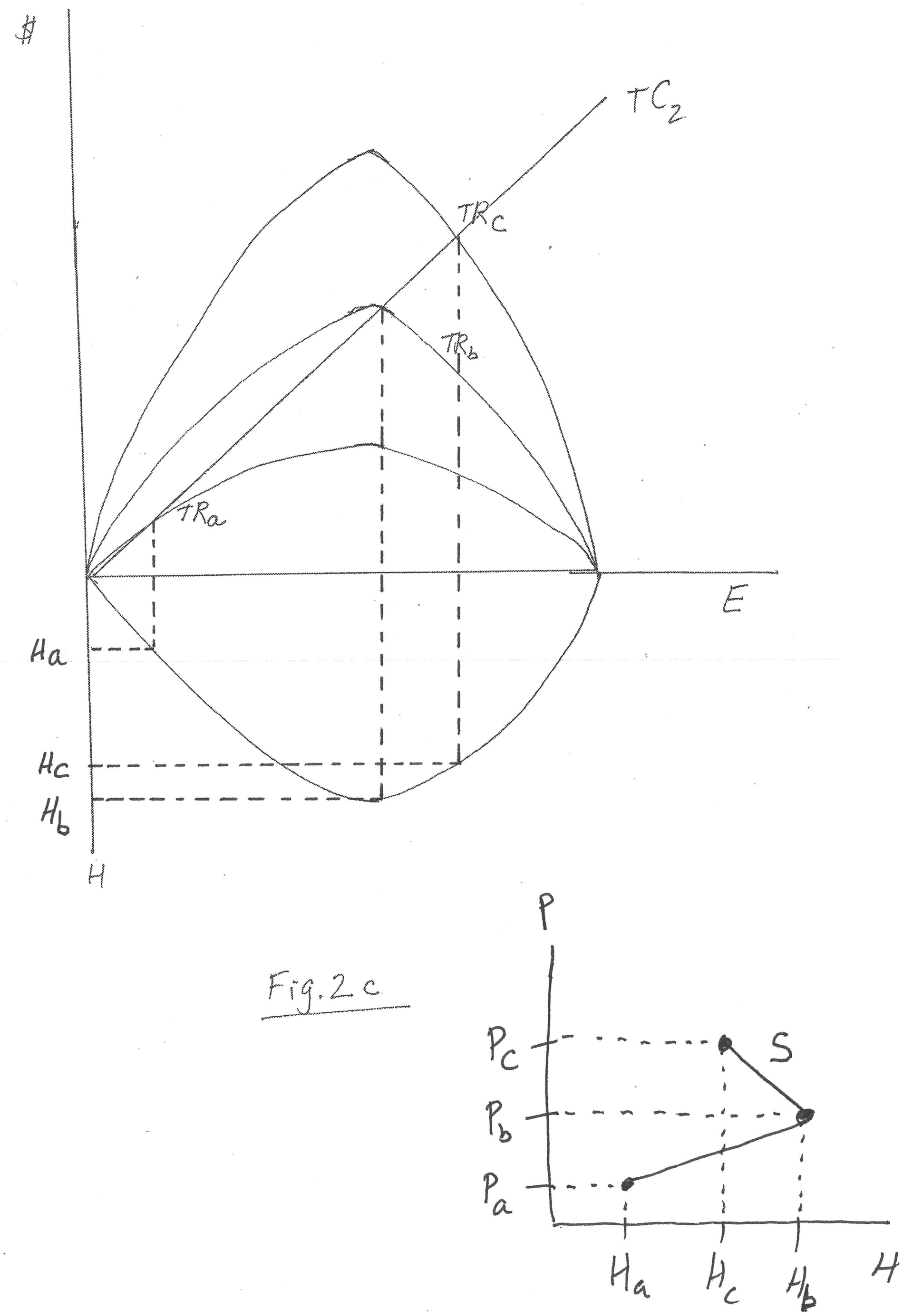


Fig. 2c

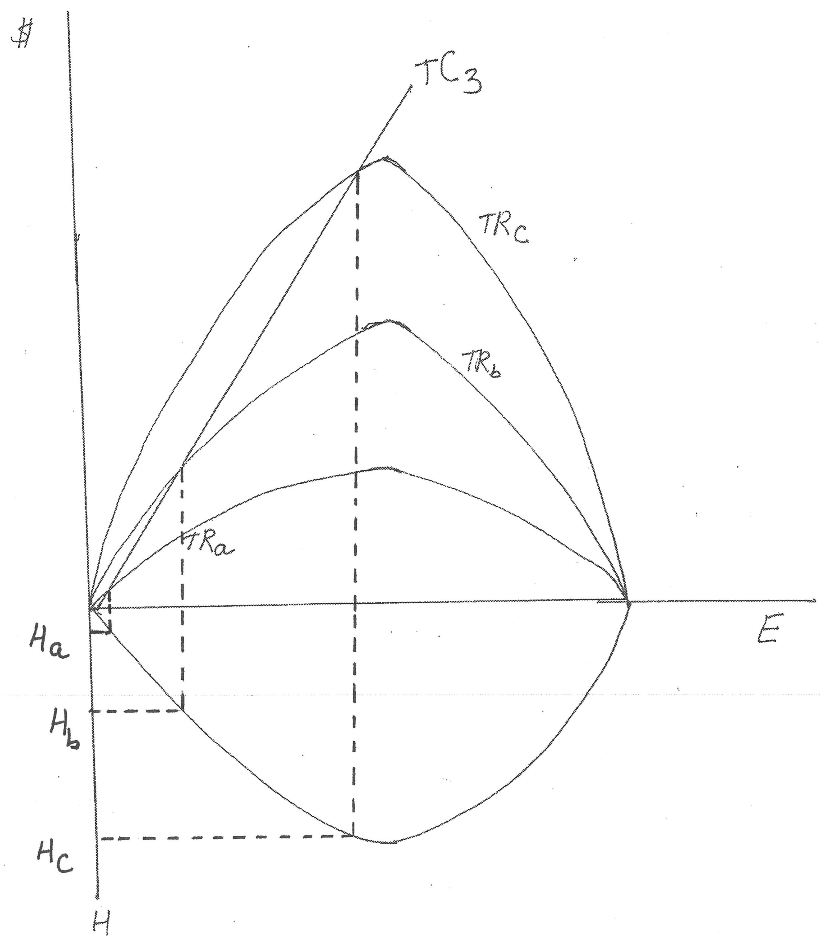
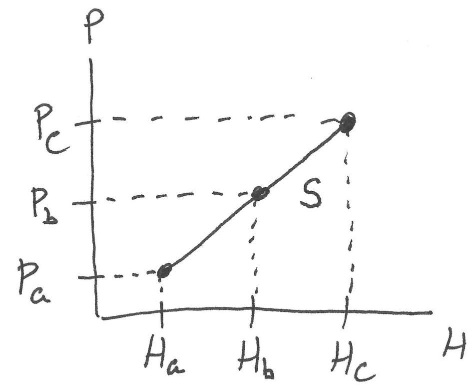
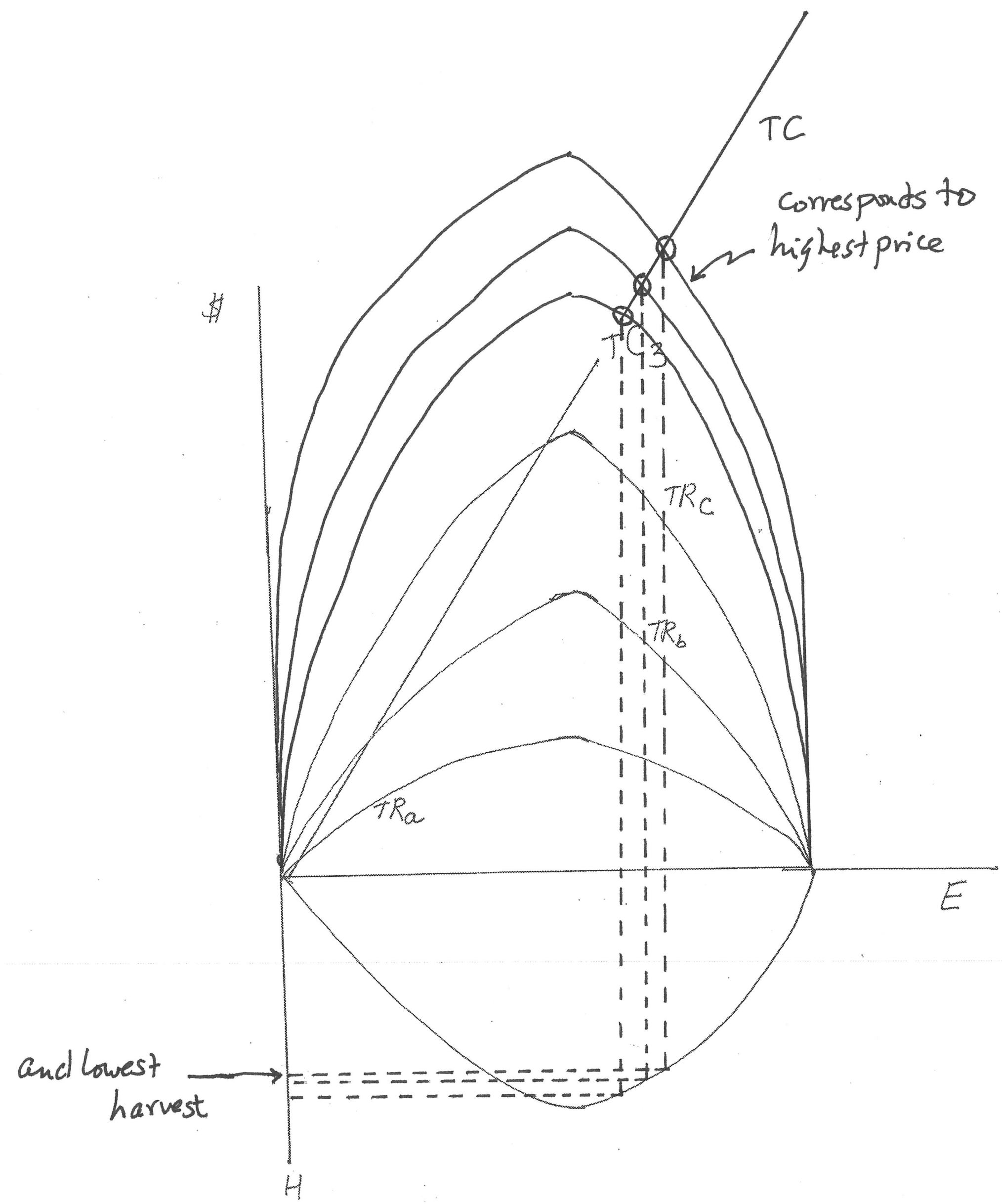


Fig. 2d

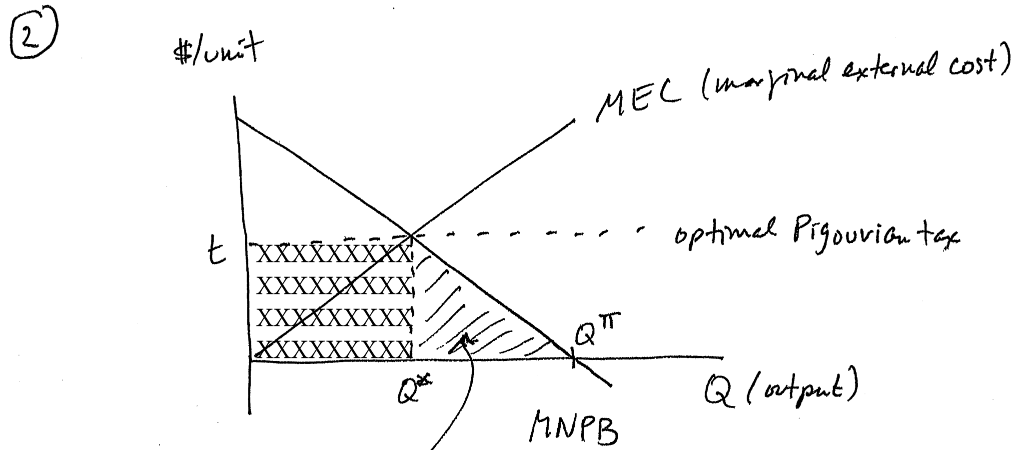




TC
corresponds to highest price
$
TC3
TRc
TRb
TRa
E
and lowest harvest
H

Fig. 2d

4. Fall 2006 Midterm Exam, Question 2. Its answer appears below, in handwriting; however, a better answer includes the typewritten additions to the answer.



Added in 2016: the "net private benefit lost due to the tax" should include the area marked with X's, which is the tax payment made by the firm (and hence lost by the firm). It is not lost to society; it is just a transfer from the firm to the government. The area shaded in the 2006 answer is lost to the firm and lost to society, because those units are never created if there is a tax. It's good for society to lose those units, because they create a lot of external costs.

shaded area = net private benefit lost due to the tax

(Net Private Benefit = area under MNPB)

Tax "t" changes output from Q^π to Q^*.

Q^* is optimal because it makes marginal social benefit MNPB − MEC equal to zero.

The firm will produce $Q < Q^*$ because MNPB > t there, but it will not produce $Q > Q^*$ because there MNPB is insufficient to cover t.

5. (a) The federal government sets environmental standards. That is, it specifies how clean air and water need to be. The states enact policies to achieve those standards. If the standards are achieved, the area is called an "attainment" area (because the area "attained" the standard). In attainment areas, the federal government exercises no more control than described in this paragraph's first sentence. If the standards are not achieved, the area is called a "non-attainment" area (because the pollution standard was 'not attained'), and the federal government requires the state to come up with a better plan to reduce the pollution. If the federal government thinks the state's plan will likely work, then it lets the state implement its plan. If the federal government thinks the state's plan is likely not to work, then the federal government could write its own regulations and take over from the state the task of monitoring compliance.

   "Attainment" or "non-attainment" areas are often smaller than a state.

   (b) The reason is that it was felt that imposing the same requirements on "old" facilities as those imposed on "new" facilities would be too costly for the "old" facilities. It's usually more expensive to bring an old facility into compliance with more stringent pollution standards than to construct 'a new facility to the more stringent standards as opposed to constructing the new facility to the less stringent standards.'

   Disputes arise from arguments about the definition of "old" versus "new" facilities after renovation of an existing facility. If the renovations were sufficiently minor, presumably the facility should retain its classification as an "old" facility; but what does "minor" mean? How "minor" is "minor"? 5%? 20%?

   Furthermore, what if a facility undergoes several "minor" renovations? At what point do a sum of "minor" renovations become a "major" renovation that changes the facility's classification from "old" to "new?"

   Note 1: A student pointed out that the basic problem underlying this question was considered by ancient Greek philosophers:

   > "The ship of Theseus, also known as Theseus' paradox, is a thought experiment that raises the question of whether an object that has had all of its components replaced remains fundamentally the same object. The

> paradox is most notably recorded by Plutarch in *Life of Theseus* from the late first century. Plutarch asked whether a ship that had been restored by replacing every single wooden part remained the same ship."—`https://en.wikipedia.org/wiki/Ship_of_Theseus`

Optional: These were major points of dispute during the administration of President George W. Bush.

Note 2: Such a distinction between "old" and "new" facilities creates incentives for firms to continue operating "old" facilities rather than construct "new" ones. That is a bad thing for the environment, but it has not in the past caused a major dispute, as far as I know.

6. Fall 2009 Exam 1 Qu. 6

7. Most of the people in Santa Monica want to protect the environment. Their new requirement that all new single-family homes in the city be zero-net energy (ZNE), meaning that they must produce more power than they consume, shows this environmental commitment, because ZNE houses could not cause any net greenhouse-gas emissions to occur. [By the way, achieving ZNE houses is much easier in extremely mild climates such as Santa Monica's than in more typical climates.]

   Rationally, then, they would take other steps to help the environment, and no steps to hurt it; or, at least, they would be very reluctant to take steps which would hurt the environment, and would only do so if the associated non-environmental benefits were very large.

   The article makes clear that many Santa Monicans believe that high-density land use (such as tall buildings) hurts the environment, so they oppose it. Looked at in isolation, it may seem true that tall buildings hurt the environment. They bring many people to the area or house many people, and the more people there are, the less "natural" an area is.

   However, the article makes clear that in terms of global warming, higher-density land use would be very helpful in reducing the US's greenhouse-gas emissions. So the Santa Monicans advocating against high-density (tall) buildings are supporting a policy which will make global warming worse, although they think such a policy would be pro-environment.

   The argument would conclude that these Santa Monicans are not behaving rationally, or, at a minimum, are behaving with such poor information that they are hurting a cause which is very important to them, even though much better information is relatively easy to get.

   Note: The question tells you to *argue* against the "people are rational" position. In contrast, it would be possible to use this article to argue *in favor* of that position. One would do this by saying what the Santa Monicans really care about is not the environment, but the market value of their homes (and the land the homes are on). Opposing the construction of tall buildings increases the value of their homes, making them richer: so, according to the argument of this "note," their behavior *is* rational.