7.1   The earth holds only a limited quantity of oil. If we continue consuming it at the present rate, it will all be gone eventually. What form of regulation is appropriate to deal with this threat?

No regulation is needed, and government intervention will be harmful, because there is no market failure. Just because a resource is going to be used up is not a sign of market failure. Indeed, it would be wasteful not to use up a resource, unless it is something that can be used without reducing the quantity, e.g. a lake for swimming,where more swimming does not reduce the size of the lake. The price of oil reflects its scarcity and its value compared to substitute sources of organic chemicals and energy. As it becomes scarcer, the price of oil will rise and consumption will decline, unless the economy grows at a fast enough rate that the value of using the oil increases demand even if the price rises. As oil becomes higher in price, substitutes will used, such as natural gas, ethanol, or synthetic oil.

Note that there may be other reasons to regulate oil, just as in any market. For example, oil creates negative externalities through traffic congestion or pollution, and the OPEC cartel tries to use its market power to keep the price high, both forms of market failure. But just being in limited supply does not mean a product needs regulation.

7.2   Why is there a better case for government regulation of fishing than for government regulation of copper mining?

Overfishing is a common-pool resource problem. If there is no regulation, a prisoner's dilemma exists in which each fisherman will catch too many fish now, ruining future fishing. The fishermen would be better off if there were limits on the annual catch for each of them. Copper mining has no such problem. Each miner can mine the copper on his own land, and the only effect on others is to slightly reduce the price of copper, which is a pecuniary externality, not a real externality.

7.3   Chateau LaTour is one of only five "premier grand cru" red Bordeaux wines. In 2013 a bottle of the 2004 vintage cost $664 (http://www.wine-searcher.com/find/ch+latour/2004). It will be at its optimal age

to drink around 2020. What can you predict about the price of this wine?

We can predict that the price of the wine will rise over time until 2020. The price will rise gradually, at a rate that makes owners indifferent between holding and selling. If it was always at the 2020 price, nobody would want to hold it as an asset rather than selling it immediately. This is a different from oil, because the wine actually improves with age up to 2020, but that just means that maybe none will be used up till then.

Reference: "The Price of Wine," Dimson, Rousseau, Spaenjers, J. Financial Econ., 2014.

7.4   How does inefficiency arise in a common-pool resource problem, and why does bargaining under the Coase Theorem not always prevent the inefficiency? You may use an example or use a general case.

Consider the example of cod, a common pool resource. Without regulation, each fisherman will catch as much as he can, because he gets the entire benefit of his catch but he shares the loss in reproduction of new fish with other fishermen. That loss to other fishermen is a negative externality, so he does too much of the activity— fishing. Bargaining fails to solve the problem because the fisherman are separated from each other and because any bargain would have to include potential new fishermen too. Transaction costs are one of the reasons efficiency fails under the Coase Theorem, and here the transaction cost of negotiation for this large number of people would prevent the bargain from occurring.

7.5   Explain how the price path of a nonrenewable resource over time depends on the discount rate and the price of the backstop technology.

All of the resource must be used up when the price rises to the price of the backstop technology, since nobody would want to hold an asset that doesn't have dividends and doesn't rise in price. While it is being used up, the price must rise at the discount rate. If it rose more slowly, then owners would want to sell it since it wouldn't yield as much as other investments, and that would make the present price drop. If it rose faster, people would want to buy more, so the price would rise and the rate of increase before the price hit the backstop technology would have to fall.

It is not simply that the quantity of the product is declining

so the price rises. First, that doesn't explain why the discount rates matters. Second, that confuses the total amount left of the product—which is declining—with the amount consumed per year, which depends on the price that year. We can imagine a declining price path (not increasing) that would use up the resource, so that each year more would be consumed. The problem with that is that once the resource ran out, the price would jump to the price of the backstop technology— but if that were so, anybody who held back some of the resource to sell would get a huge one-year profit, so everybody would hold back and we couldn't have that big jump.

7.6 Discarded.

7.7   In Sunnyvale, households may put out up to three garbage cans plus a recycling bin for paper and glass, mixed together. Private hauling is not allowed to compete with the city curbside service. The city takes the nonrecycled garbage to a private landfill that charges $30/ton. It takes recycled garbage to a private recycling company that pays the city $5/ton. The cost of the labor and trucks to get the garbage delivered to the private companies is $10/ton for nonrecycled garbage and for recycled garbage it is $14/ton. The average householder would pay $40 per ton of recyclables ($.02/lb) not to have to sort his recyclables from his other garbage.

(a) What is one change the city could make to increase social surplus? Explain.

(b) What is another change the city could make to increase social surplus? Explain.

Three good answers are:
(i) Allow competition from private companies, so costs will fall.
(ii) Require households to pay the city for each garbage can they put out. It costs the city $40/ton, and charging the households the appropriate amount per garbage can will make them throw out less garbage.
(iii) If policy (ii) is adopted, require households to also pay the city for each recycling bin they put out, but make the fee lower. It costs the city $9/ton for recycling (netting out the price the recycling company pay the city), so it is important to make recycling cheaper than simple garbage for the households, though we must still worry about their recycling too much if recycling is free. Note that the average household would not recycle under this policy, but that does

not mean nobody would recycle— some people have lower costs, or even enjoy sorting out their recyclables.

It is not a good answer to require households to limit the amount of garbage they put out. That can be highly inefficient if a household generates a lot of garbage and would have to keep it in their house because the city wouldn't pick it up and wouldn't allow private haulers either. Imagine a family with three kids in diapers!

7.8   In Germany, every household has a blue garbage can for paper, a yellow one for metal and plastic, a brown one for biodegradable kitchen scraps, and a gray one for other things. Also at various places in the city are white, green, and brown bins for various colors of glass and orange bins for batteries. See "German Idiosyncrasies, Second Edition," and "USAG Ansbach Recycling/SORT Guide.") The government's cost of dealing with recyclables is only 25% as much as for the same weight of non-recyclables. What are the implications of this policy for Germany's national surplus?

If Germans really enjoy recycling, regarding it as entertainment rather than a chore, then this policy will raise national surplus compared with requiring people to do their recycling privately, though it would be best to allow people who did not enjoy recycling to put everything into their gray garbage cans. It seems the German government loses money on both nonrecycled garbage and recycled garbage, so it would also make sense to make people who throw out more things pay more for their garbage service, with a higher price for gray-can garbage than for the other kinds. On the other hand, a huge amount of home labor and space for ugly multicolored garbage cans is required, so if citizens would not recycle voluntarily, it reduces national surplus to require them to use their land and labor for this activity.

7.9   Suppose oil is costless to obtain from natural sources, that we can synthetically produce oil at a cost of $200/barrel, that the current price is $80/barrel, and that we expect the price of oil to hit $200/barrel in 2050.

(a) What combination of natural and synthetic oil will be used after 2050? Explain.

(b) This year, a new synthetic process is unexpectedly discovered that only costs $180/barrel. What happens to the path of price and natural

oil consumption?

(a) Just synthetic, no natural. Since the price will no longer be rising, it would be pointless to wait to sell your oil till 2050. Production will be chosen to exactly use up all natural oil in that year.

(b) There will immediately be a sharp drop in the price of oil to below \$80/barrel. The price will then resume rising until all the oil is used up when the price reaches \$180/barrel.

7.10   A number of local and state governments have started refusing to allow old televisions to be thrown away in their landfills, and direct that they be taken by the owner to special recycling centers instead. In *Journal of Hazardous Materials* 177: 251-259 (2010) Seong-Rin Lim and Julie Schoenung say:

> "... although a proper landfill liner system should contain the metals for the short-term, the long term scale for landfill treatment is on the order of 1000 years, and therefore landfill treatment can ultimately return the constituents of waste to the ecological cycle through chemical, physical, and biological reactions and transformation ... it is assumed that all of the heavy metals included in e-waste have the potential to impact human health and the ecosystem through water medium...

There do not seem to be any findings of heavy metals (e.g. lead) leaching from any landfills in the United States yet, only a fear that it might happen, and landfills are highly regulated to prevent that. It is nonetheless true that we do not know whether landfills will remain safe for 1,000 years. Is the banning of televisions from landfills a wise response to this concern?

The 1,000-year argument misses two things. First, it ignores discounting. The discounted value of any harm that comes in 1,000 years is very small. Put differently, if we could spend X now to prevent harm in 1,000 years, we must consider whether the people 1,000 years from now would prefer that we invest X so they can have $X(1+r)^{1000}$ instead of having the harm prevented.

Second, the 1,000-year argument ignores the possibility of waiting and addressing the problem later. If we wait, maybe the landfill will never start leaking and we won't have to spend anything. Or, if the landfill started leaking 200 years from now, the problem could

be addressed at that point by repairing the landfill, delaying the time at which we have to pay to prevent the harm.

The policy also ignores the incentives it creates for people with old televisions. The policy makes it difficult to dispose of them in landfills, so we need to be concerned that people will get rid of them in other ways, e.g. to drop them off illegally in the woods, which is much worse than in even a low-quality landfill.

CHAPTER 8: MONOPOLY

8.1   The demand curve for widgets is Q=24-P. Marginal cost is constant at 4 and the fixed cost is 1. One firm has a monopoly.   What price will the firm choose?

The demand curve can be rewritten as $P = 24 - Q$. $Profit = PQ - 4Q - 1 = (24 - Q)Q - 4Q - 1 = 24Q - Q^2 - 4Q - 1$. The derivative of profit with respect to Q is $24 - 2Q - 4$. Setting that equal to zero, we get $20 - 2Q = 0$ so $Q = 10$. From the demand curve, the price is then $P = 24 - Q = 14$.

8.2   The demand curve facing a firm is P= 6 - Q/2 and its marginal cost is MC=2Q.

(a) What is the monopoly output?

(b) At the monopoly output, would an increase of 1% in the price cause revenue to rise, or to decline?

(a) Marginal revenue is found from the demand curve, $P = 6 - Q/2$. It is $MR = 6 - Q$, sloping down twice as fast so it hits the Q-axis half as far down as the demand curve does. Or,

$$MR = (dP/dQ)Q + P = (-.5)Q + (6 - Q/2) = 6 - Q.$$

Then $MC = MR$ yields $2Q = 6 - Q$, so $Q = 2$.

Or, you could find the Q that maximizes total profit. If the marginal cost is 2Q, then the total cost is Q^2. Having realized that, and ignoring any possible fixed cost, profit is

$$PQ - TC = (6 - Q/2)Q - Q^2.$$

Differentiating with respect to Q and setting the derivative equal to zero yields

$$6 - Q - 2Q = 0$$

so Q=2.

(b) Revenue would decline. The decline in sales would be more than 1%, because demand is always elastic at the monopoly price. A firm with marginal cost of zero will maximize revenue, and so will choose a price where the elasticity is -1, so any firm with positive cost will choose a price that makes demand elastic. If revenue would rise from a decline in quantity and an increase in price, the firm would have raised the price already, because that would both increase revenue and reduce costs (because Q would fall).

You can see this from the Lerner Condition too, because it says that at the monopoly price and output,

$$(P - MC)/P = -1/(elasticity)$$

Since $P - MC < P$, it must be that the elasticity is between -1 and $-infinity$, so it is elastic.

Or, you could see that $P = 5$ and $(5 - 4)/5 = -1/(elasticity)$, so the elasticity is -5.

You could also compute out the actual elasticity, though I didn't expect that much detail. The elasticity is $(dQ/dP)(P/Q)$. Rewriting demand by solving the demand equation for Q we get $Q = 12 - 2P$. Thus, $dQ/dP = -2$. If Q =2, then P=5, so the elasticity is $(-2)(5/2) = -5$, very elastic.

8.3   The company Apex has a total cost of $TC = 2 + 4A$ and the company Brydox has a total cost of $TC = B$, where A and B are their outputs. The market demand facing both firms is $Q = 36 - P$, where $Q = A + B$.

(a) Find an equation for Apex's reaction curve.

(b) Find Apex's equilibrium output.

(c) What is the equilibrium price?

(a) Apex's profit function is

$$\begin{aligned} Profit(Apex) &= PA - TC_a \\ &= (36 - A - B)A - 2 - 4A \\ &= 36A - A^2 - BA - 2 - 4A \\ &= 32A - A^2 - BA - 2 \end{aligned}$$

Differentiating yields

$$dProfit/dA = 32 - 2A - B = 0,$$

so $32 - B = 2A$ and $A = 16 - B/2$, which is the reaction function.

(b) Brydox's profit function is

$$Profit(Brydox) = PB - TC_b = (36 - A - B)B - B = 36B - B^2 - BA - B = 35B - B^2 - BA$$

Differentiating yields

$$dProfit/dB = 35 - 2B - A = 0,$$

so 35-A = 2B and B= 17.5-A/2, which is the reaction function.

Solving this with A's reaction curve yields:

$$A = 16 - B/2$$
$$A = 16 - \frac{(17.5 - A/2)}{2}$$
$$A = 16 - 8.75 + A/4$$
$$\frac{3A}{4} = 7.25$$
$$A = 9.67$$

(c) Since $A = 9\frac{2}{3}$, we can substitute into Brydox's reaction function, $B = 17.5 - A/2$, to get $B = 17.5 - 29/6 = 12\frac{2}{3}$.. The demand curve is $Q = 36 - P$, so $(58/6 + 76/6) = 36 - P$ and $P = 13\frac{2}{3}$.

8.4 Discuss whether the firm should raise its price in each of the following situations:
(a) Demand facing the firm is inelastic.
(b) Total market demand is inelastic, but demand facing the firm is perfectly elastic.
(c) The elasticity of demand is -3 and the firm's marginal cost is 10.

(a) The firm should raise its price, because the percentage increase in price will be greater than the percentage fall in quantity sold, so revenue will rise and costs will fall.

(b) The firm should not raise its price. If it does so, it will sell nothing, because other firms will be charging a lower price. Since total market demand is inelastic, if all the firms raised their prices together, they'd all make more profits, but if just one firm raises its price, the market price stays the same.

(c) This one's not so clear. It depends on the firm's current price. If the firm raises its price, its revenue will go down— but its costs will go down too, because it won't have to produce as much.

The Lerner Rule says to set price so that $(P - MC)/P = -1/elasticity$. Plugging what we know into that, $(P - 10)/P = -1/(-3)$, or $1 - 10/P = 1/3$. Then $10/P = 2/3$, and $P/10 = 3/2$ so $P = 15$. If the price starts out higher than this, the firm should reduce it, and if the price starts out lower, the firm should raise it.

Note that if the price is currently at 12 or 18, so it needs changing, 15 probably is not the optimal price. If the price starts out higher than 15, and the company lowers it, then demand will probably get more inelastic because of the move down the demand curve. Thus, in the end the optimal price might be 13— we don't have enough information to tell exactly.

8.5   Someone proposes to reduce the deadweight loss from a monopoly by imposing a sales tax, paid by the seller. Discuss whether this plan could work, using a diagram.

The plan will not work; deadweight loss will increase. The monopoly is pricing higher than $P = MC$ to begin with, pricing at the Q_0 where $MC(Q) = MR(Q)$. Adding a tax is like increasing the MC of the monopoly, so it will reduce Q so that $MC(Q_1) + T = MR(Q_1)$. Reducing the output moves Q further away from the efficient level, so deadweight loss rises by the grey shaded amount on the diagram.
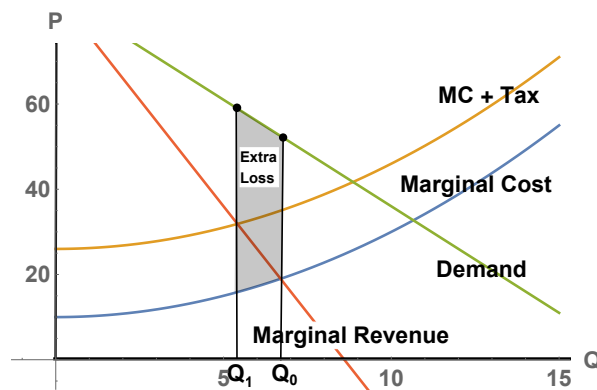
8.6   Which of the following firms is violating the anti-trust laws? (there might be more than one) Give at least a sentence of explanation for

each (this is not a multiple choice question)
(a) Acme has a profit margin of 80% of price over average cost.
(b) Brydox and Central, each with 4% of the market, have agreed to
each cut output by 10%.
(c) Dataco has a market share of 93%.
(d) Exron has grown to control half of the city's garbage collection by
sending death threats to its competitors and killing their pets.

(a) Acme is not violating; high profits are not illegal.
(b) Brydox and Central are violating— agreements on quantity or
price are per se illegal.
(c) Dataco is legal; high market share is not against the law.
(d) Exron is illegal. This is an anti-trust offense of monopolization,
as well as a normal criminal offense (extortion, and I'm sure there's
some law against killing dogs).

8.7   Let the demand curve be $Q = 23 - P$ if $P \leq 23$ and 0 otherwise.

(a) If there is one firm, with a marginal cost of 1 for outputs less than
8, a marginal cost of 3 for outputs greater than 8, and a fixed cost of
2, what will be its output and price?

 (b) If there are two firms with marginal costs of 1 each and fixed
costs of 2.7 each, what will be the output of each firm according to
the Cournot model? What will happen to output if the fixed costs
increase to 3 for each firm?

(a) Suppose output is less than 8, so MC=1. Revenue is $PQ =$
$(23 - Q)Q = 23Q - Q^2$, so, taking the derivative with respect to
Q, marginal revenue is $MR = 23 - 2Q$. If we try to set this equal
to MC=1, we would get $1 = 23 - 2Q$ and $Q = 11$, but that output is
too high for the MC=1 to be valid. Trying MC=3, if MC=MR then
$3 = 23 - 2Q$ and Q=10. In that case, P = 13.

Note that the fixed cost is irrelevant to the price.

(b) Firm 1's profit function is $\pi_1 = PQ_1 - TC_1 = (23 - Q_1 - Q_2)Q_1 -$
$1Q_1 - 2.7) = 23Q_1 - Q_1^2 - Q_2Q_1 - Q_1 - 2.7 = 22Q_1 - Q_1^2 - Q_2Q_1 -$
2.7. Setting the derivative equal to zero, we get $22 - 2Q_1 - Q_2 = 0$,
so $Q_1 = 11 - Q_2/2$.

Since the firms are symmetric, $Q_1 = Q_2$. Therefore, $Q_1 = 11 -$
$Q_1/2$, so $(1.5)Q_1 = 11$ and $Q_1 = 22/3$, or 7.33...

An increase in the fixed cost will have no effect.

8.8   Apex and Brydox compete in selling identical car axles to auto companies, setting quantities A and B. Apex has a marginal cost of 20 and a fixed cost of 2. Brydox has a marginal cost of 0 and a fixed cost of 4. Demand is $Q = 50 - P/2$.

(a) What is Apex's reaction function?

(b) What is Brydox's reaction function?

(c) What are the equilibrium values of A and B? What is the equilibrium price?

(a) $P = 100 - 2(A + B)$. $Profit_A = (100 - 2(A + B))A - 20A - 2 = 100A - 2A^2 - 2AB - 20A - 2$.

Differentiating, we get $80 - 4A - 2B = 0$, so $80 - 2B = 4A$.

This solves to the reaction function $A = 20 - B/2$.

(b) $P = 100 - 2(A + B)$. $Profit = (100 - 2(A + B))B - 4 = 100B - 2AB - 2B^2 - 4$.

Differentiate to get $100 - 2A - 4B = 0$.

This solves to the reaction function $B = 25 - A/2$.

(c) Substitute $A = 20 - B/2$ for A in Brydox's reaction function to get $B = 25 - [20 - B/2]/2$.

Solve this, noting that it comes to $B = 25 - 20/2 + B/4$, not $-B/4$, and you get $B = 20$. Then $A = 20 - B/2 = 10$ and the price is $P = 100 - 2(A + B) = 100 - 2(10 + 20) = 40$.

8.9   Suppose that in the benzene market the market shares of the three top sellers are 20%, 30%, and 40% and the 10 remaining firms each have market shares of 1%.

(a) What is the Herfindahl Index for this industry?

(b) Would the Justice Department and FTC be likely to allow merger of the 10 small firms?

(a) 20*20+30*30+40*40 + 10*1*1 = 400+900+1,600+10 = 2,910.

(b) Merger of the 10 firms would change their contribution to the Herfindahl from 10 to 1*10*10 = 100, an increase of 90. The merger would end up with the industry "highly concentrated", since the Herfindahl would be over 2,500. The Guidelines say that mergers that raise concentration by less than 100 are almost always permitted, so the antitrust authorities will probably permit the merger.

8.10   Two companies who propose to merge admit that the elasticity of demand facing them would be lower after the merger, but say that production costs would be much lower.

(a) Is it possible that the merger would reduce prices? Explain.

(b) Show, using a diagram, a scenario under which the merger could raise total surplus even if the price rose.

(a) The merger could reduce prices if the cost savings were great enough. In a competitive market, price =MC, but if that MC is lower in the monopolized market, the price at the quantity where MC=MR might be even lower.

(b) If the two firms merge and marginal cost falls from C_0 to C_1, but the price rises from P_0 to P_1, producers gain X+V-Z, while consumers lose W+Y. Then net gain is X-Y-Z, which can be positive, as in the diagram: the cost savings exceeds the increase in the triangle loss from monopoly underproduction.