Econ 131
Spring 2022
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Problem Set 3 Solution

DUE DATE: April 20

Student Name:

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- **You must submit your solutions using this template.**
- **Although you may work in groups**, each student must submit individual sets of solutions. You must note the names other students that you worked with. Write their names here:

1. Essay (6 points)

As discussed in class, the state of California is at the vanguard of efforts to decarbonize its economy. The following "almanac" summarizes these efforts: `https://www.energy.ca.gov/sites/default/files/2022-02/2021_EnergyAlmanac_ADA.pdf`

How do they compare with the economists' prescription that the best remedy is to set a carbon tax equal to the marginal damage of carbon emissions and just let the free market work? As global warming is due to global emissions, does it make sense for a small jurisdiction such as California (at the global scale) to take unilateral bold steps to decarbonize?

Solution: This corrective tax is indeed the classic view of economists derived from the standard model of externalities. It is striking that none of the steps in "almanac" takes the form of tax on carbon. The tax on carbon key practical weakness is that it is a regressive consumption taxes and hence is very unpopular. Therefore, it is more effective in practice to directly subsidize and mandate renewable energy.

If each jurisdiction (state or country) plays a purely selfish strategy, it indeed does not make sense to be first mover in decarbonization: California bears the costs of decarbonization and the cut in emissions favors the full world (free rider problem). Hence, economists have typically argued for a coordinated approach through binding treaties (such as Kyoto 1997). In practice, there could be a lot of value for a small jurisdiction in demonstrating that decarbonization is possible. Once the demonstration is done, others can follow. It makes a lot of sense that the richest countries (CA is among the richest states in the most advanced economy in the world) start and then the model can be followed more cheaply by poorer countries (developing countries). Furthermore, decarbonization requires developing new technologies and there is a big advantage in being the first developer and then dominate the global market in new technologies (e.g., both the US and China would want their own country companies to dominate such a future global market).

2. True/False Statements (10 points)

Determine whether each statement is true, false, or uncertain and explain why. Answers with no explanation will receive no points.

(a) Suppose that candidates X and Z run for president. Candidate X is elected president after winning 51% of the vote. Then once in office, he appoints more conservative members to the Supreme Court than candidate Z would have. This means that a majority of American voters preferred more conservative Supreme Court members. (Assume that everyone is fully informed about the candidates plans and the President does not need Senate approval to appoint Supreme Court members.)

UNCERTAIN. This is possibly true. It's also possible that voters are single-issue voters on several topics and that X assembles a coalition large enough to win and then does things that only a minority of voters support. For example, X could get elected by 26% of voters who care only about conservative Supreme Court members and another 25% of voters who care only about low tax rates on high-earners (which X supports but Z does not). Then it's possible that only 26% of voters support conservative Supreme Court member appointments.

(b) There is no reason for the government to impose social distancing to fight the epidemic because private agents can create markets to price the corresponding externality.

False: This is theoretically true based on the famous Coase theorem we discussed in class. However, in practice, this is an externality involving many agents and there is no way in practice that such a market could develop. In practice, the only way to get the proper level of social distancing is through mandated government orders.

(c) As CO2 emissions create a classic externality, the only policy needed to solve the problem is a tax on carbon that would apply in all countries at the same rate and set equal to the marginal damage created by CO2 emissions.

FALSE. This is the classic view of economists derived from the standard model of externalities. However, as we discussed in class, there are great difficulties in pricing the cost of the externality. Furthermore, carbon taxes might suffer from popular opposition as they are regressive (e.g., yellow vests in France, developing countries that want cheap sources of energy). Instead, the key goal should be decarbonization which can happen through a combination of policies: government mandated transition, subsidies to innovation in renewables, development of renewable infrastructure, and possibly a path of increased carbon taxes.

(d) The returns of education accrue primarily to the person receiving the education and hence the government should not be heavily involved in the provision of education.

FALSE: While it is true that the returns of education accrue primarily to the person receiving the education, there are compelling reasons why the government should be involved (and that explains why the government is actually involved in practice). Most important ones: 0) everybody should have access to education to have a chance of succeeding economically, 1) parents with low incomes may not afford education for their kids, 2) kids cannot borrow on their own to get an education, 3) people are not able to navigate well the education "market" (lack of good information, susceptible to false advertisement, etc.)

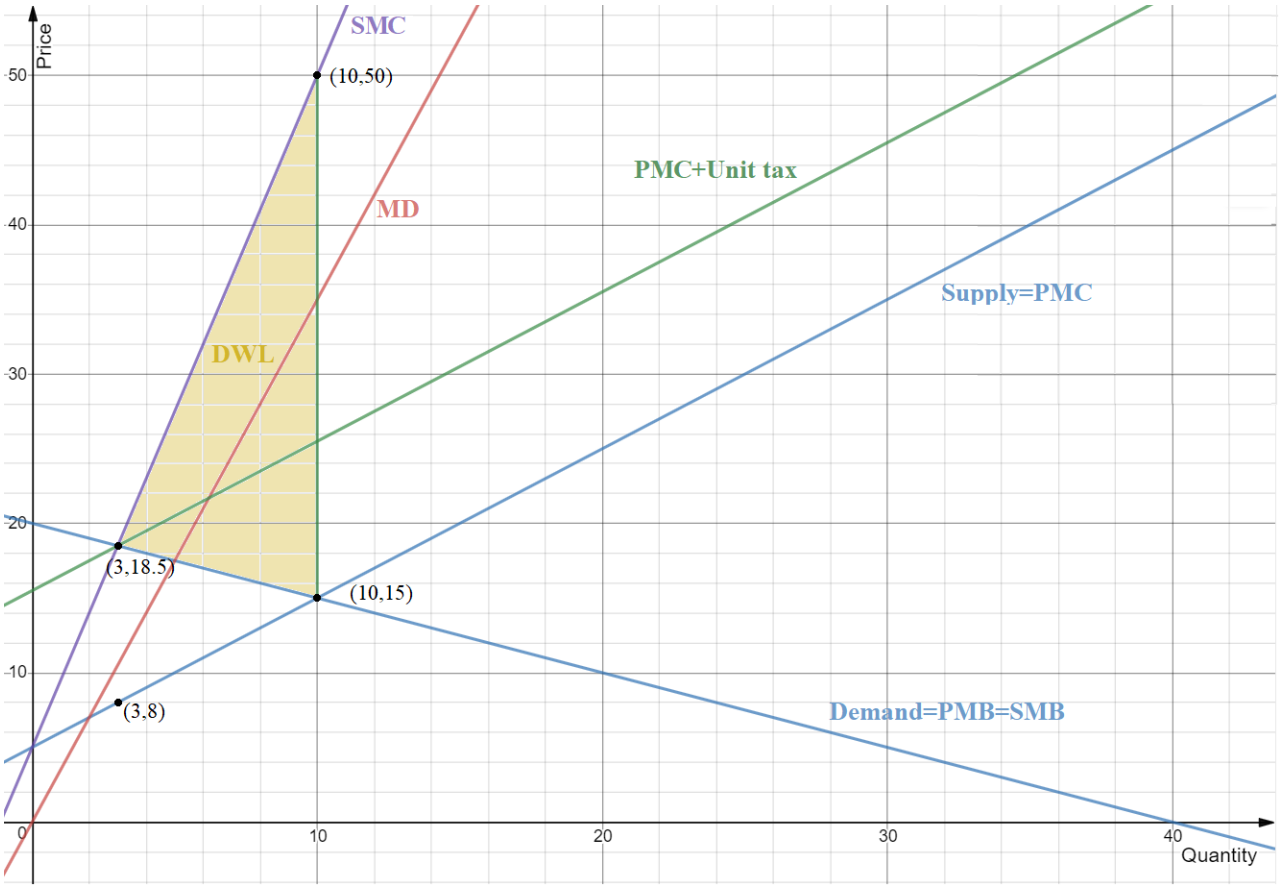
(e) According to the Tiebout model, local public good provision is efficient and tailored to the tastes of local residents. Hence, it is better to have a fully decentralized government.

FALSE: True if all public goods are local and society does not care about redistribution. False if there are global public goods (like national defense and expertise in solving problems that require coordination such as pandemic fighting). False if society cares about redistribution as local governments cannot do as much for redistribution given mobility threats (see class notes).

3. Externalities

A coal-fired power plant releases air pollution into the atmosphere for every unit of electricity produced. The inverse demand function for coal-fired electricity is $P_d = 20 - \frac{1}{2}Q$, which represents the marginal benefit curve where Q is the quantity consumed when consumers pay price P_d. The inverse supply curve for coal-fired electricity is $P_s = 5 + Q$, which represents the marginal private cost curve when the power plant produces Q units. The marginal damage from emissions is given by $MD = 3.5Q$, which describes the cost of greenhouse gas emissions and local air pollution when the industry generates Q units of coal-fired electricity.

a) Illustrate the market for the coal fired electricity with a supply/demand graph. Be sure to draw the curves for demand, supply, marginal damage, and social marginal cost.



b) What are the equilibrium price and quantity for coal fired electricity when there is no correction for the externality?

Setting $P_d = P_s$ results in $P_{priv} = 15$ and $Q_{priv} = 10$.

c) How much coal fired electricity should the market supply at the social optimum?

We see that $SMC = P_s + MD = 5 + Q + 3.5Q = 5 + 4.5Q$ Setting $P_d = SMC$, $20 - 0.5Q = 5 + 4.5Q$, gives $15 = 5Q^*$, ie $Q^* = 3$ and $P^* = 18.5$

d) How large is the deadweight loss from the externality?

DWL here is the added cost to society by producing more than the social optimum. The price difference between $P = 5 + 4.5Q$ and $P = 5 + Q$ at $Q = 10is(5 + 45) - (5 + 10) = 35$. The change in quantity between the private Q and optimal Q is 7 $DWL = 1/2 * 35 * 7 = 122.5$

e) Is it possible for the government to achieve the social optimum by imposing a per-unit fee on emissions? If not, explain why it is not possible. If so, how large must the emission fee be if the market is to produce the socially efficient amount of coal fired electricity? Also, draw the firm's supply curve with the new emission fee on your graph.

It is possible: We want $SMC = P_S$ at Q^*. We choose a tax so that $P^* = 5 + Q^* + t$, ie $18.5 = 5 + 3 + t$, so $t = 10.5$. That tax is equal to the amount of marginal damage at the socially optimum quantity.

4. Public Goods

A home slightly south of campus has two residents: Arlen and Ben. All cleaning of the home is done solely through the individual efforts of the two residents, who, after eating and sleeping and socializing have **49** hours a week to devote to some combination of studying and cleaning. Arlen's utility over studying and cleaning is given by $U_A = 20 \log S_A + 4 \log C$ and Ben's utility over studying and cleaning is given by $U_B = 20 \log S_B + 5 \log C$, where C is the total cleaning done in the apartment, given by the sum of each individual's contribution: $C = C_A + C_B$.

a) How much time do Arlen and Ben each spend studying and cleaning?

Solution:

If each resident optimizes his own function, he will choose the amount of cleaning that maximizes his own utility, taking into consideration the cleaning done by the other resident.

Arlen's studying time, S_A, can be rewritten as $49 - C_A$ because all the time not spent on cleaning (C) can be spent on studying.

The public good enjoyed by Arlen can be rewritten as $C_A + C_B$ because public goods provided by either one are consumed by both.

Therefore, Arlen's utility function can be rewritten as

$$U_A = 20 \cdot log(49 - C_A) + 4 \cdot log(C_A + C_B).$$

Set $\partial U / \partial C_A$ equal to zero:

$$-20/(49 - C_A) + 4/(C_A + C_B) = 0$$
$$20/(49 - C_A) = 4/(C_A + C_B)$$

Cross-multiply, $20(C_A + C_B) = 4(49 - C_A)$, and expand: $20C_A + 20C_B = 196 - 4C_A$.
Solving for C_A yields $C_A = (196 - 20C_B)/24$.
The same procedure for Ben yields $C_B = (245 - 20C_A)/25$

These are response functions. They allow each resident to calculate his optimal C as a function of the contribution to C made by the other resident.

Plugging Ben's response functions into Arlen's response function yields

$$
\begin{aligned}
C_A &= \frac{196 - 20C_B}{24} \\
C_A &= \frac{196 - 20 \cdot \frac{245 - 20C_A}{25}}{24} \\
24 \cdot C_A &= 196 - 196 - 0.8C_A \\
23.2 \cdot C_A &= 0 \\
C_A &= 0
\end{aligned}
$$

Then Ben will spend $C_B = (245 - 20 \cdot 0)/25 = 9.8$ hours cleaning and $S_B = 49 - 9.8 = 39.2$ hours Studying, while Arlen will spend 49 hours studying and won't contribute to cleaning at all.

b) What is the socially optimal amount of time that they should spend? If your answer differs from part a), why?

Solution:

The social planner maximizes $U_A + U_B$ by choosing $\{S_B, S_A, C_A, C_B\}$ subject to the budget constraints $49 = S_A + C_A$ and $49 = S_B + C_B$. This is equivalent to maximizing the following Lagrangian:

$$max_{\{S_B,S_A,C_A,C_B\}} L = [20log(S_A) + 4log(C_B + C_A)] + [20log(S_B) + 5log(C_B + C_A)] + \lambda_1(49 - S_A - C_A) + \lambda_2(49 - S_B - C_B)$$

Which gives first-order conditions:

(i) $\frac{20}{S_A} - \lambda_1 = 0$

(ii) $\frac{9}{C_B+C_A} - \lambda_1 = 0$

(iii) $\frac{20}{S_B} - \lambda_2 = 0$

(iv) $\frac{9}{C_B+C_A} - \lambda_2 = 0$

(v) $49 - S_A - C_A = 0$

(vi) $49 - S_B - C_B = 0$

There are a bunch of constraints, but they simplify quickly. Notice from (ii) and (iv) that $\lambda_1 = \lambda_2 = \frac{9}{C_B+C_A}$. Then using $\lambda_1 = \lambda_2$, we know from (i) and (ii) that $\frac{20}{S_A} = \frac{20}{S_B}$ or $S_A = S_B$ which we can define as S_i. Then from (v) and (vi) we know that $C_A = C_B = 49 - S_i$, and so $S_i = 49 - C_i$. Then, from (i) and things we have derived we know that $\frac{9}{C_B+C_A} = \frac{20}{S_i}$, or $C_i = \frac{9}{40}S_i = 100 - C_i$. Solving, we get $C_i = 9$ or $C = C_A + C_B = 9 + 9 = 18$ and $S_A = S_B = 40$.

Intuitively, in the computation in part (a), we set the marginal utility of the last hour of cleaning to each resident equal to the marginal utility of studying for that resident. In part (b), we set the sum of the marginal utilities of the last hour of cleaning - the social marginal utility of cleaning - equal to the marginal utility of studying for either resident. Since the social marginal utility of cleaning exceeds the individual marginal utilities of that hour of cleaning, a central planner optimally chooses more time on cleaning than individuals would if they were acting alone.