EC1340 – Fall 2018

Final Exam
2:00-3:30pm, December 27, 2018
Matt Turner

You will have 90 minutes to complete this exam. No notes or books are allowed but you may use a calculator. Cell phones and any device with a wireless connection must be off. Anyone still working on their exam after time is called will be subject to an automatic 10 point penalty.

When you write up your answers, your goal should be to (1) be correct, and (2) convince your reader that your answer is correct. Answers which do not achieve these goals will not be awarded full credit. To accomplish the second objective, it is helpful if your work is legible and if all steps are presented, possibly with a line of explanation. Total points =100/Share of total grade =35% . Total pages = 2.

This exam has TWO pages.

1. (8) Why is 'AAU' an important acronym if you want to understand how the Kyoto protocol worked?

2. (20) The Manchester Street Power plant in Providence is gas fired and can generate about 500 mega watts (MW) of power. If it averages 50% capacity for a year, then it will generate $365 \times 24 \times 250\text{MW} = 2.2$ million mega watt hours (MWH) per year.

   The Manchester Street plant has been gas fired for 23 years. Calculate how much cooler the world would be in 2100 if this plant had been nuclear rather than gas fired during this time.

   You may find the following constants useful for this calculation: Nordhaus rule of thumb, doubling CO_2 concentration from 280ppm to 560ppm causes 3 degrees Celsius of warming by 2100; 1ppm of atmospheric carbon weighs 2.12 Gt; one MWH of gas fired power causes about 0.5 tons of CO_2 emissions; 0.55 of each unit of CO_2 emissions remains in the atmosphere after one year; 44/12 tons of CO_2 contains one ton of carbon.

3. In their 1995 paper in American Economic Review, Mendelsohn et al estimate the relationship between US agricultural land rent, and temperature and rainfall in four seasons. Simplifying a little, they estimate that

$$\text{rent/acre} = 1490 - 57 \times \text{January temp} + 75 \times \text{January rain} + \epsilon,$$

   where rainfall is inches and temperature is degrees Fahrenheit.

   To make things easy, suppose that initial January temperature and rainfall are zero. Suppose that there are two competing climate models. The first predicts 1 degree of warming and 2 inches of rain for January. The second predicts 2 degrees of warming an one inch of rain. Finally, suppose that ϵ is a random variable that takes the values 100 and minus 100 with equal probability.

   (a) (4) Calculate the expected change and standard deviation of land rent if the first climate model is correct. Repeat these calculations when the second climate model is correct.

   (b) (4) Suppose that you think both climate models are equally likely and that the draws of ϵ are independent of which model is true. Calculate the expected value and standard deviation of land rent for this case.

   (c) (4) In this example, does climate model uncertainty increase or decrease our uncertainty about the effect of climate change on land rent? Explain briefly.

4. This problem asks you to identify the optimal type of regulatory instrument—price or quantity—in an environment where the planner is uncertain about the firm's costs.

   Let

$$\begin{aligned} B(y) &= y - \frac{1}{2}y^2 \\ C(y) &= \eta y + \frac{1}{4}y^2, \end{aligned}$$

   where η is a random variable that affects the firm's costs. Define η as follows:

$$\eta = \begin{cases} 1 & p = \frac{1}{2} \\ 0 & p = \frac{1}{2} \end{cases}.$$

   The planner must choose between optimal quantity regulation, y^* and optimal price regulation $\widehat{p}$.

   (a) (10) Establish analytically whether quantity or price regulation is socially optimal.

   (b) (10) Draw a graph that illustrates: Marginal cost function (in each state of the world), the marginal benefit function, optimal price regulation $\widehat{p}$, firm response to price regulation $\widehat{y}(\widehat{p})$ and optimal quantity regulation y^*. Also illustrate the deadweight loss from each instrument in each state of the world.

5. Consider a fishery with N fishers. Let

$$\begin{aligned} K &= \text{stock of fish} \\ x_i &= \text{effort by fisher } i. \\ \left(\sum_{j=1}^{N} x_j\right)^{\frac{1}{2}} K^{1-\frac{1}{2}} &= \text{harvest} \\ w &= \text{price of effort.} \end{aligned}$$

   This exercise asks you to characterize market and rent maximizing exploitation behavior.

   (a) (8) Find the first order conditions for x_i^1 under open access. To do this assume symmetry, so that $X = \sum_{j=1}^{N} x_j$ and $x_j = X/N$. Make this substitution in the first order conditions and take the limit as $N \to \infty$.

   (b) (8) Let $N = 1$ and find the first order conditions.

   (c) (4) Explain the differences between the two sets of FOC's. Draw a graph like those that Gordon draws to illustrate both sets of FOC's.

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Solutions

1. In the Kyoto Protocol, AAU is an 'assigned amount unit'. Each such unit permits the holder to emit one ton of CO2. These are the emissions permits that the Kyoto Protocol envisioned would form the basis for an international market in tradable CO2 emissions permits.

2. 2.2×10^6 MWH/year $\times 23$ years $\times 0.5$ CO2/MWH $\times 12/44$ C/CO2 $= 6.9 \times 10^6$ tons of C emitted by the Manchester Street power plant since conversion to gas. Of this, 0.55, or 3.8×10^6 tons stays in the atmosphere.

   Dividing by 2.12×10^{12} gives us the resulting change in atmospheric concentration of Carbon, or $\frac{3.8\times 10^6}{2.12\times 10^{12}} = 1.8 \times 10^{-6}$ppm of C.

   From Nordhaus' rule of thumb, increasing concentration from 280 to 560 pmm increases temperature by 3 degrees Celsius, or 3/280 degrees per 1 pmm of concentration. Thus emissions from the Manchester Street plant should lead to about $\frac{3}{280} \times 1.8 \times 10^{-6} = 19 \times 10^{-3} \times 10^{-6} = 19 \times 10^{-9}$ degrees of warming in 2100.

3. (a) Under the first climate model land rent is a lottery, $R_1 = (1483{,}1683{,}\frac{1}{2}{,}\frac{1}{2})$. Under the second climate model, we have $R_2 = (1351{,}1551{,}\frac{1}{2}{,}\frac{1}{2})$.

   The expected values of these lotteries are:

$$\begin{aligned} E(R_1) &= \frac{1}{2}(1483) + \frac{1}{2}(1683) \\ &= 1583 \\ E(R_2) &= \frac{1}{2}(1351) + \frac{1}{2}(1551) \\ &= 1451 \end{aligned}$$

   The standard deviations of these lotteries are:

$$\begin{aligned} sd(R_1) &= [\frac{1}{2}(1483 - 1583)^2 + \frac{1}{2}(1683 - 1583)^2]^{\frac{1}{2}} \\ &= 100 \\ sd(R_2) &= [\frac{1}{2}(1351 - 1451)^2 + \frac{1}{2}(1551 - 1451)^2]^{\frac{1}{2}} \\ &= 100 \end{aligned}$$

   (b) If we think each climate model is equally likely then land rent is described by the compound lottery $R_3 = (R_1{,}R_2{,}\frac{1}{2}{,}\frac{1}{2}) = (1483{,}1683{,}1351{,}1551{,}\frac{1}{4}{,}\frac{1}{4}{,}\frac{1}{4}{,}\frac{1}{4})$. Calculating mean and standard deviation in the usual way, we have $E(R_3) = 1517$ and $SD(R_3) = 119.8$.

   (c) Since model uncertainty increases the standard deviation of our predictions under either model, it increases our uncertainty.

4. (a) First, find the optimal quantity regulation y^*,

$$\begin{aligned}
&\max E(B(y) - C(y)) \\
&= \max E(y - \frac{1}{2}y^2 - \eta y - \frac{1}{4}y^2) \\
&= \max y - \frac{3}{4}y^2 - E(\eta)y \\
&= \max y - \frac{3}{4}y^2 - \frac{1}{2}y \\
&= \max \frac{1}{2}y - \frac{3}{4}y^2
\end{aligned}$$

The first order condition is $\frac{3}{2}y = \frac{1}{2}$, so $y^* = \frac{1}{3}$

Substituting y^* into the last of the set of equations above, we have that $W(y^*) = \frac{1}{2}(\frac{1}{3}) - \frac{3}{4}(\frac{1}{3})^2 = 1/12$.

Now find the firm's response to price regulation, $\hat{y}(p)$. The firm solves

$$\begin{aligned}
&\max py - C(y) \\
&= \max py - \eta y - \frac{1}{4}y^2
\end{aligned}$$

The first order condition here is $y = 2(p - \eta)$, so we have $\hat{y}(p) = 2(p - \eta)$. Note that the firm observes its costs and so does not make decisions under uncertainty.

Next, use the firm's response function to find the best price regulation, $\hat{p}$. In this case, the planner solves,

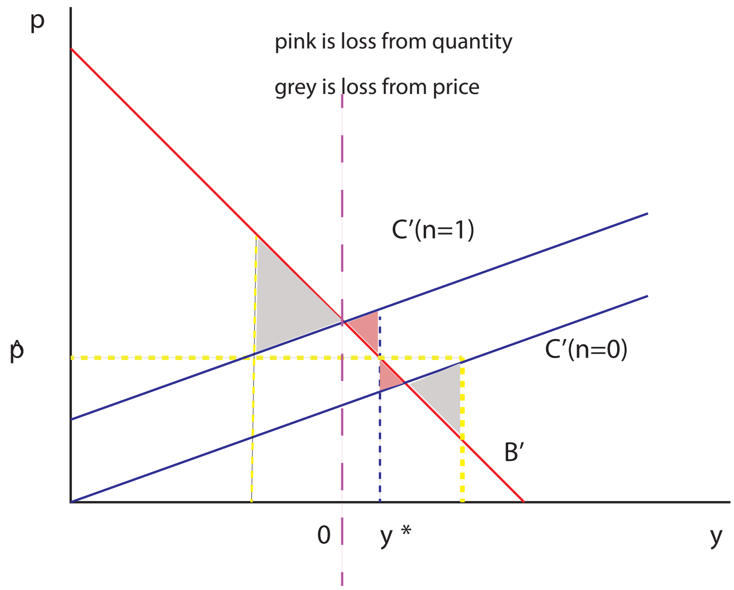
$$\begin{aligned}
&\max E(B(\hat{y}(p)) - C(\hat{y}(p))) \\
&= \max 4p - 3/2 - 3p^2
\end{aligned}$$

The first order condition is $4 - 6p = 0$ so we have that $\hat{p} = 2/3$.

Substituting $\hat{p} = 2/3$ into $\hat{y}(p)$ gives $\hat{y}(p) = -2/3$ or $4/3$ depending on η. This is a bit tricky, and if you truncated y at zero, it's OK. I'm not going to in my solutions.

Substituting $\hat{p} = 2/3$ in the last of the equations above, we have that $W(\hat{p}) = 4(2/3) - 3/2 - 3(2/3)^2 = -1/6$.

Thus, $W(\hat{p}) < W(y^*)$ and quantity regulation is optimal.



(b)

5. (a) Fisher i chooses x_i to solve

$$\max \frac{x_i}{\sum_{j=1}^{N} x_j} \left(\sum_{j=1}^{N} x_j \right)^{\frac{1}{2}} K^{\frac{1}{2}} - w x_i$$

taking as given the behavior of the other fishers.
The optimal choice of x_i is determined by the first order condition

$$\begin{aligned} 0 &= \frac{d\pi}{dx_i} \\ &= \left[\frac{1}{\sum_{j=1}^{N} x_j} - \frac{x_i}{(\sum_{j=1}^{N} x_j)^2} \right] \left(\sum_{j=1}^{N} x_j \right)^{\frac{1}{2}} K^{\frac{1}{2}} + \left[\frac{x_i}{(\sum_{j=1}^{N} x_j)} \right] \frac{1}{2} \left(\sum_{j=1}^{N} x_j \right)^{-\frac{1}{2}} K^{\frac{1}{2}} - w \end{aligned}$$

Now assume symmetry. That is, let $X = \sum_{j=1}^{N} x_j$ and $x_i = x_j = X/N$ for all i,j.

$$\Longrightarrow$$

$$0 = \left[\frac{1}{X} - \frac{X/N}{X^2} \right] (X)^{\frac{1}{2}} K^{\frac{1}{2}} + \left[\frac{X/N}{X} \right] \frac{1}{2} (X)^{-\frac{1}{2}} K^{\frac{1}{2}} - w$$

As $N \to \infty$ all of the terms involving $X/N \to 0$ and we are left with,

$$w = \left[\frac{1}{X} \right] (X)^{\frac{1}{2}} K^{\frac{1}{2}}$$

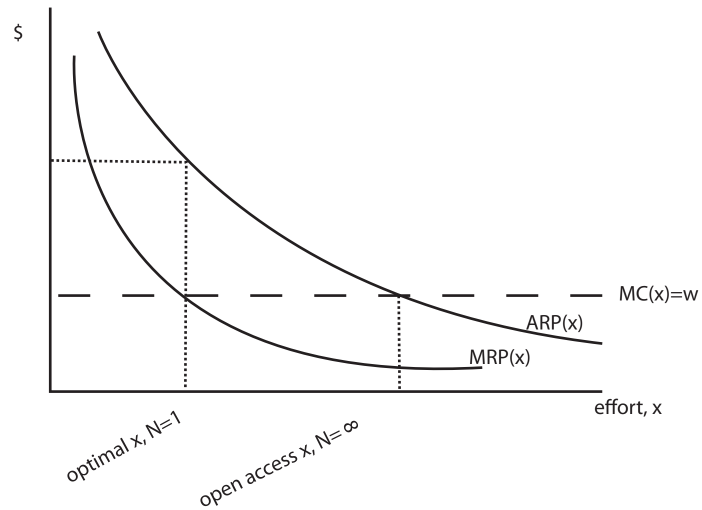
which is ARP(x)=MC(x), just as in Gordon.

(b) if $N = 1$ then $x = X$ and our first order condition is

$$\begin{aligned} w &= \left[\frac{1}{X} - \frac{1}{X} \right] (X)^{\frac{1}{2}} K^{\frac{1}{2}} + \frac{1}{2} (X)^{-\frac{1}{2}} K^{\frac{1}{2}} \\ &= \frac{1}{2} (X)^{-\frac{1}{2}} K^{\frac{1}{2}} \end{aligned}$$

but this is just $MRP(x) = MC(x)$

(c) Your graph should look like this:



In the first part of this problem we have $ARP = w$ in the second part we have $MRP = w$.