Past Exams

Economics of the Environment and Natural Resources/Economics of Sustainability

K Foster, CCNY, Spring 2012

These can give you an idea of the sorts of questions that might be asked on this year's exam. As always, past performance is no guarantee of the future.

Exam from 2011 given as take-home

You are to download the exam from Blackboard sometime between 12:01am on Wednesday April 13, 2011 and 11:59 pm on Monday April 25, 2011.

Within 24 hours of downloading the exam, you must submit your answers electronically on Blackboard and/or by email (to kfoster@ccny.cuny.edu). If you hand-write your answers and scan in the papers, you must ensure that you have time and facilities to do this before 24 hours is up.

Statement of Academic Integrity

> *By submitting answers to this exam, each student asserts that all the work is his/her own.* Submitted answers must follow the CUNY Guidelines on Academic Integrity (http://www1.ccny.cuny.edu/upload/academicintegrity.pdf). Study aids such as computer programs, textbooks, notes, websites, and other such references are approved. Previous discussions with other students in the class are allowed. However, since the exam was handed out, students must have **no** communication about this exam with anyone else, from the time the exam was obtained until the time the answers were submitted. All answers ought to be honestly your own. Violations of Academic Integrity will be punished.

1. (50 points) Carefully specify your view of the debate on the economics of climate change. What target of CO2 seems to balance the costs and benefits? Why do you estimate these costs and benefits (e.g. discount rate)? What particular action (tax, tradable permits, regulation or no action), at what particular level of abatement (higher or lower), seems optimal? What would be the objections of some of the authors we've been reading (e.g. Stern, Nordhaus)? How would you rebut those objections – what evidence supports your viewpoint rather than theirs? Why would a policymaker choose your side? (A good essay might efficiently use 800-1500 words, possibly with graphs, tables, graphics, and/or equations.)

   Answers will vary. More points were awarded for essays that cited the views of the other authors and carefully explained their positions and the interrelated objections.

2. (25 points) Consider two polluters with different production technologies; one produces emissions as $E_1 = y^3$, so the Marginal Rate of Transformation is $3y^2$; the other produces emissions as $E_2 = y^2$, so its MRT is $2y$. Suppose that regulators set a policy where no firm is allowed to produce more than 10 units of emission.
   a. How much output can firm 1 make? How much output can firm 2 make?
   b. Is this policy socially efficient – is there a way for society to make as much output but fewer emissions?
   c. What other regulatory policies could achieve a better outcome?
   d. Why might a regulator nevertheless optimally choose this type of regulation over, say, tradable permits?

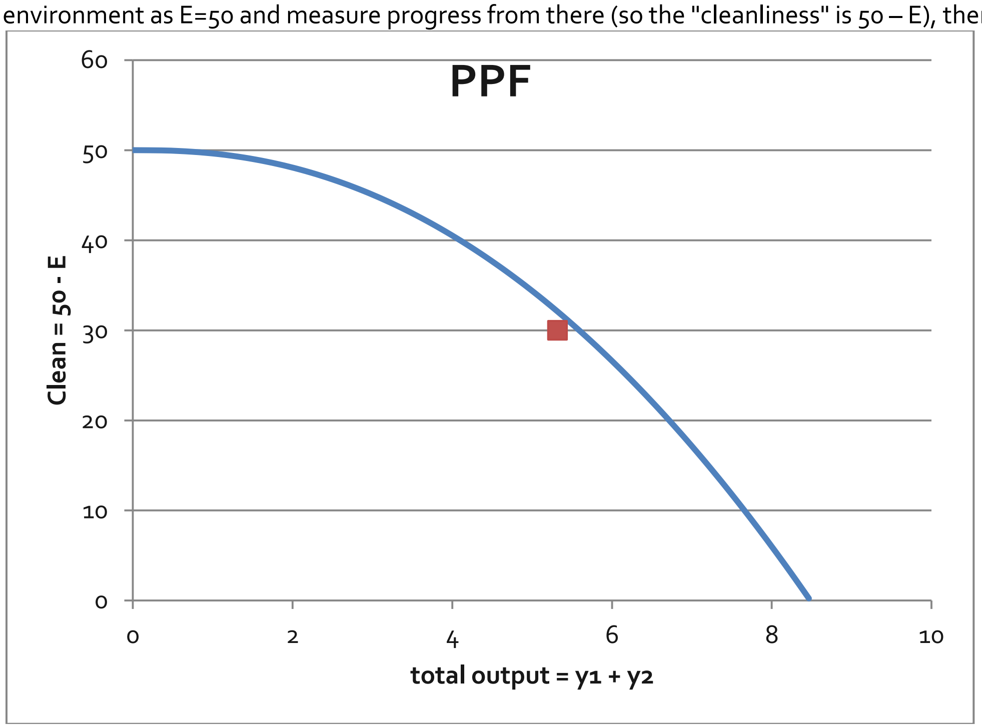
   Put in E=10 for each and find $y_1 = \sqrt[3]{10} = 2.15$ and $y_2 = \sqrt{10} = 3.16$ under the "command and control" method of capping each firm's emissions at 10. However this is not socially efficient: the Marginal Rates of Transformation are unequal, which means that the "price" in terms of emissions of the final unit of output is unequal for the two firms.

   A straightforward calculus-of-variations argument shows this. Suppose firm 2 were to make one more unit of output while firm 1 made one less; this results in the same total output of Y (5.32) but now, instead of getting 20 units of emissions, we only get $(2.15-1)^3 = 1.54$ emissions from firm 1 and

$(3.16+1)^2 = 17.32$ units of emissions from firm 2 – a total of 18.86 units of emission even while making the same amount of output (firm 1 reduces emissions by 8.46; firm 2 increases emissions by 7.32). Put otherwise, the firms could make more output for the same emissions.

We can think of this in terms of the Production Possibility Frontier: society trades off between output and emission (in politics, jobs vs environment). We can't have both huge output and clean environment and must make tradeoffs. Different people would want different tradeoffs but all could agree that the first step is to get to the frontier – if there were a way to increase output while reducing emissions, then both sides are happier.

Derive the PPF by setting the MRTs equal: $3y_1^2 = 2y_2$; solve to find $y_1 = \sqrt{\frac{2}{3}y_2}$. Total output is defined as Y = $y_1 + y_2$; at optimum this is $Y = \sqrt{\frac{2}{3}y_2} + y_2$. Total emissions are E = $E_1 + E_2$; at optimum this is $E = \left(\sqrt{\frac{2}{3}y_2}\right)^3 + y_2^2$. If we choose (somewhat arbitrarily) to define a perfectly dirty environment as E=50 and measure progress from there (so the "cleanliness" is 50 – E), then the PPF is



The red box shows the situation with emission cap; it is not on the frontier.

Superior policies would get to the frontier; a Pigouvian emissions tax or a cap-and-trade (tradable permits) might be able to provide incentives for firms to reduce emissions below the cap. Of course different choices of where to set the cap (at 20 or 15 or 25) would mean different prices for permits.

Similarly the level of the tax cannot be specified without knowing which part of the PPF the society desires to hit (remember the tax and price of a permit are equivalent). For example if society wants E=20 then at this point firm 2 should make about 3.96 units of output where its MRT is 7.92 and firm 1 should make 1.62 where its MRT is also 7.92. This means that for both, making one more unit of output creates 7.92 more emissions so an emissions tax should make a unit of emission cost as much as 1/7.92 of the output.

There are many reasons why regulators might nevertheless prefer the command-and-control cap to more sophisticated policies. The cap gives a clear deterministic standard. The cap stops local effects being too bad: neighbors of firm 2 might be willing to suffer 10 units of emission but more than 15 (as implied by the PPF) might be awful.

3. (25 points) Consider a simple model of an emission permit market. Suppose there are two sorts of firms with different Marginal Costs of Emissions: dirty firms have Marginal Cost of Emissions (MCE) $MCE = \frac{12}{E_d}$, where Ed are the emissions of dirty firms. Cleaner firms have $MCE = \frac{10}{E_c}$, where Ec are emissions of cleaner firms. Assume that each firm gets 8 permits; there are 10 clean and 10 dirty firms.
   a. How many emission permits are available to the firms?
   b. The structure of the permit market means that 10Ec + 10Ed equals the total number of permits issued. Use this equation to get Ec as a function of Ed.
   c. If clean firms had a Marginal Cost of Emissions higher than dirty firms, what action would you expect to see?
   d. If, instead, clean firms had a MCE lower than dirty firms, what would you expect to see?
   e. Therefore what must be true in equilibrium, for the MCE of each type of firm?
   f. What does this imply must be the amount of emissions for each type of firm?
   g. What price of permits does this imply (i.e. what MCE)?
   h. Were regulators to show new lenity and give each firm 9 permits, what would be the change in the permit price?

   There are 20 firms that each get 8 permits so 160 permits in total. With ten firms of each type, this means that 160 = 10Ec + 10Ed and so Ec = 16 – Ed.

   If clean firms had MCE higher than dirty firms then the clean firms would want to buy more permits, which would increase their quantity of emissions and thus (since MCE is proportional to the reciprocal) decrease their MCE. Vice versa if the dirty firms had a higher MCE: there would be an incentive to trade. Trading will stop when the MCEs are equal. So in equilibrium, $\frac{12}{E_d} = \frac{10}{E_c}$.

   Combine the equations to find $E_c = \frac{10}{12} E_d = 16 - E_d$ so $E_d = \frac{96}{11}$ = 8.73 and Ec = 7.27; each has MCE = 1.375 and that is the price that each would pay for a permit.

   If instead there were 9 permits per firm so 18 in total, then would solve $\frac{10}{12} E_d = 18 - E_d$. So Ed = 9.82, Ec = 8.18 and the price is 1.22 (a lower price).

Exam from 2010 given in class

The questions are worth 120 points. You have 120 minutes to do the exam, one point per minute. All answers should be put into the blue books or typed up and submitted online.

You may refer to your books, notes, calculator, computer, or astrology table. The exam is "open book."

However, **you must not refer to anyone else, either in person or electronically**!

You must do all work on your own. Cheating is harshly penalized.

Please silence all electronic noisemakers such as cellphones.

Good luck. Stay cool.

1. (40 points) What do you believe is the best policy to abate carbon emissions? Your answer should cite specific readings that address the costs and benefits of the policy you advocate; compare these with the costs and benefits of other policies. Your grade is determined not by which policy you choose (the section where you state your choice might be one of the shortest) but by how effectively you marshal the evidence. *(You can type or write your answer.)*

Answers will vary.

2. (20 points) Please explain your planned final topic. Explain one additional academic reading on the topic (or more if you're feeling geeky). What is the main question posed by the paper? What research methods are used? What conclusion is drawn? What factors are omitted? How would the inclusion of these change the conclusion (if at all)?

Answers will vary.

3. (20 points) Maple farms have externalities in production. The trees are tapped (to get the sap to make maple syrup) for just 6 weeks of the year; in the remaining 46 weeks of the year the healthy forest provides ecosystem services such as water preservation and storm water control (the NY State Comptroller just released a report on these sorts of benefits). Suppose that the marginal private cost (supply) of maple can be represented as $P = Q + 5$. The marginal external benefit can be modeled as worth an additional $0.5Q$. Demand can be represented as $P = 50 - 2Q$.

   a. In the absence of policy, what level of production would be predicted in a free market? At what price?

   Set supply equal to demand so $Q + 5 = 50 - 2Q$ and $Q=15$, $P=20$.

   b. Graph supply, demand, and the external benefit. What is the Deadweight Loss from the absence of policy? What is the socially optimal amount of production?

   The social optimum would be where the total social cost $Q + 5 - .5Q = .5Q + 5$ equals demand, so $.5Q + 5 = 50 - 2Q$ so $Q^*=18$ and $P^*=14$; the private market undersupplies forest. The DWL is therefore the triangle with height $(20 - 16)$ and width $(18 - 15)$ so area is 6.

   c. What government policies could attain the social optimum? What size subsidy or tax? Quantity regulation?

   The government could require that existing farms produce more but this would be unprofitable to the industry. Or the government could subsidize production; a subsidy of size S would shift the private supply curve to $Q + 5 - S$; so private-market equilibrium would be $Q = (1/3)(50 - 5 + S) = 15 + S/3$. To get to 18 would require a subsidy of 9 (which could also be calculated as $0.5Q^*$, the size of the production externality).

   d. Suppose the government just set the price (decreeing the appropriate price) -- what would happen?

   Just regulating the price to be 14 would result in only $Q=9$ being produced by the farms while 18 would be demanded -- there would be queues.

4. (20 points) The City of New York has a problem with CSO events (combined sewage overflow). The costs of controlling storm water can be modeled as a two-part function: for levels of wastewater, X, less than 100, the MCC is high: $MCC = 300 – 2X$; for levels of X greater than 100, $MCC = 150 – 0.5X$. The MDC is $0.5X$.

   a. If there were no regulations, how much wastewater would be emitted?

   We would find where $MCC = 0$, which is $X=300$ (on the second part of the MCC). This would cause substantial damage, $MDC = 150$.

   b. If you were working for the state DEC to regulate emissions, what would you calculate to be the socially optimal amount?

   Find where $MCC = MDC$; set $.5X = 150 - .5X$ and solve $X^*=150$ at cost of 75.

   c. What tax would provide incentive for the city (assume it acts as if it were maximizing profit) to emit the socially optimal amount?

A tax of T per emission unit would make the MCC = 150 - TX - .5X; we want this to be 75 when X = 150. So 150 = 150/(.5 + T) so T=0.5.

   d. Suppose political constraints meant that the tax could only be half of the optimal size – what would be the deadweight loss?

A tax of half the optimal size, just .25 per unit, would result in emissions of 200, where MDC = 100, MCC = 50, so DWL is 1250.

5. (20 points) Suppose you are forecasting the market for carbon emissions permits over the next five years. The government will issue 500 permits; at this level the price is likely to be $15.
   a. List some of the important factors that would impact the demand for these permits.

Answers should include HIcks-Marshall factors of derived demand for factors of production.

However political pressures mean that the government may issue 25 additional permits.

   b. If the price falls to $14, what does this imply about the elasticity of demand?

If a 5% increase in supply creates a -1/15 =- 6.67% change in price, then this is an elasticity of -1.33.

Exam from earlier years

1. Consider the case of a particular pollutant which can be modeled as follows. The Marginal Savings (MS) to the producers is believed to be adequately represented as a linear function of the amount of emissions (e), as MS = 20 – e. The Marginal Damage (MD) of the pollutant upon the neighborhood residents can be approximated as a linear function of the amount of the pollutant (p, wherever the pollutant level is greater than zero) so MD = p – 5 where p>5. For simplicity we assume that the transfer coefficient is 1.
   a. If there is no cost to pollution, how much would the producers emit? What would be the marginal damage?
   b. Suppose that you are an advisor to the local EPA. Based on the above estimates of MS and MD, what is the socially optimal level of emissions, e*? What emissions tax, t*, would correspond to this level of emission?
   c. What if the MS were not actually the function above but instead were given as MS = 18 – e. What is the deadweight loss to society if emissions had been regulated by quantity with the industry regulated to produce no more than e*? What is the deadweight loss to society if emissions had been regulated by tax at t*?
   d. What if the MS were not actually the function above but instead were given as MS = 22 – e. What is the deadweight loss to society if emissions had been regulated by quantity with the industry regulated to produce no more than e*? What is the deadweight loss to society if emissions had been regulated by tax at t*?
   e. Explain why there is a deadweight loss in each case – can pollution really be "too low"?
2. Read the paper (on the Blackboard course site, last item under "Course Documents"): Schmalensee, Joskow, et al (1998), "An Interim Evaluation of Sulfur Dioxide Emissions Trading," *Journal of Economic Perspectives*. Give a detailed explanation and review of the paper. Good essays will provide a short overview of the science of why Sulfur Dioxide is regulated, the previous regulatory framework, and the implementation of the tradable permits. Discuss the choices of industry in how to clean up. Explain the likely effects of the tradable permit system.

   Conclude with a detailed explanation of what lessons ought to be applied if you were to be designing a carbon emissions trading program within the US. What part(s) of the SO_2 trading program would need to be changed to handle CO_2? What portion(s) could be transferred over? Your complete essay should be at least 1000 words; at least a third should discuss the transference to carbon.