Environmental and Resources Field Exam

Thursday, May 25th, 2017

From 1:00-4:00pm

Please answer all four questions. You have three hours to complete the exam. Put your ID on each page, on the upper corner of the page. Answer each question separately and start each question on a new page.

Good luck!

Qualifying Exam: Question from ARE 261
Spring 2017

Question 1 (2 Parts)

Part 1, True or false, with explanation

Explain both true and false responses. You may need to explicate what **additional assumptions** or conditions are necessary to provide a complete answer. (I'm expecting approximately two to four sentences per answer.)

(a) Suppose the government must raise revenue on the margin through a distortionary tax on labor supply. When the marginal cost of public funds is high, the optimal Pigouvian tax will be higher. (1 point)

(b) Suppose that the government must fund public goods through distortionary taxation on labor supply. When the marginal cost of public funds is high, the optimal quantity provided of a public good will be lower. (1 point)

THIS PROBLEM IS CONTINUED ON THE NEXT PAGE

Part 2, Algebra problem

Firms indexed $j = 1, ..., J$ produce a homogeneous product x in a competitive market. Total consumer value is $U(X)$ where $X = \sum_j x_j$, with U decreasing and concave. The private cost of producing x is common across firms $c(x_j)$, where c is increasing and convex.

Production also creates a hazardous waste w_j, and each firm produces a different amount of waste per unit of output: $w_j = \gamma_j x_j$, where γ_j potentially differs across firms. All waste is either dumped d or recycled z: $d_j + z_j = w_j$. Dumping is free for the firm, but it induces an externality per unit dumped of ϕ. Recycling causes no externality but it costs the firm $\kappa < \phi$ dollars per unit recycled.

In this problem, we will contemplate versions of a deposit-refund system. The idea here will be that the planner cannot observe dumping d_j, but it can observe output x_j and recycling z_j. The government will be able to place a tax t on output x as well as offering a subsidy r on recycled waste z. Assume the government balances any net revenue (expenditures) with non distortionary lump-sum transfers (taxes).

Note that because $\kappa < \phi$, there is no dumping in the first best. All waste is recycled.

(a) Write the planner's problem and use it to describe the first-best allocation of x_j. (1 point)

(b) Suppose that the government can set firm-specific taxes on output t_j and that it also establishes a subsidy for recycling of $\tilde{r} = \kappa$. Firms will be indifferent between dumping and recycling, so just assume that they recycle all of their waste.

- Write down firm j's profit maximization problem (you can assume that they will recycle all waste if that helps). (1 point)
- Use that problem to show what rate t_j the government should choose. (1 point)

  (Describe the answer for a generic j.)
- Explain how this relates to the Pigouvian prescription. (1 point)

(c) Continue to assume that the government has set $\tilde{r} = \kappa$, but now they must set a single tax on output t that is common across firms.

- Write a numbered list that explains the steps you would use to describe the second best tax rate t. (2 points)
- Denote the second-best tax rate as $\tilde{t}$. As time allows, derive and interpret $\tilde{t}$. (1 point)

(d) Continue to assume that the government must set a single tax rate t on all output, but now reconsider the rebate r. Should the planner set $r = \kappa$, or will a different value be optimal? An intuitive explanation is sufficient (but a derivation is welcome; or setup a problem that you could solve if you had more time). (1 point)

Part 3, Supplemental true or false, with explanation (approximately two to four sentences per answer)

(a) A monopolist produces a good called shmoo, which has a **positive** externality.

True or false: The optimal subsidy for shmoo could be larger than or smaller than the marginal external benefits at the optimal quantity. (1 point)

(b) The mayor of Springfield wants to efficiently reduce the amount of pollution generated by paper mills in her city. There are 7 paper mills operating in Springfield, each with the same constant marginal cost of abatement. The optimal amount of abatement required in the city is 1400 units. The mayor imposes a 200-unit mandatory abatement for each firm.

True or false: This mandatory regulation is not cost effective; the mayor could lower costs by introducing a trading scheme or using a tax instead. (1 point)

(c) A coal-fired power plant produces electricity, which causes pollution. A nearby laundry suffers from a negative externality due to soot from coal production. Suppose that tax policies put in place have ensured that the quantity of electricity produced by the plant is the socially optimal amount.

True or false: Coasian bargaining between the plant and the laundry might reduce social welfare. (Assume the tax still exists, and Coasian bargaining cannot change the tax.) (1 point)

(d) Suppose that a coal-fired power plant emits pollution, but an optimal cap and trade system has been put in place. Now, suppose that the power plant receives an efficiency upgrade, so that it produces more electricity per unit of coal burned. Because of the rebound effect, the plant will be used more.

True or false: The rebound effect is inefficient (it lowers social welfare). (1 point)

Part 4, Supplemental short answer questions

(a) The equations below come from our lecture notes on a congestible public good. Notation: there are many individuals indexed by i, there is a public good g, a private good x, each person may use up to the full amount of the public good $g^i \leq g$, and congestion is equal to total use of the public good and is denoted $C \equiv \sum_{i=1}^{n} g^i$. Each agent has utility that depends on their own consumption of the private and public good, and the size of the public good and total congestion: $U^i(x^i, g^i, C, g)$. The first-best allocation will include a choice of how much of the public good to provide g, and how much of the public good to let each person use g^i. The first-best allocation is described by these two equations:

$$\sum_{i=1}^{n} \frac{\partial U^i/\partial g}{\partial U^i/\partial x^i} = \frac{1}{g'}$$

$$\frac{\partial U^i}{\partial g^i} + \frac{\partial U^i}{\partial C} + \sum_{j \neq i} \frac{\partial U^j}{\partial C} = 0 \quad \text{(*assumes interior solution where } g_i < g\text{)}$$

Interpret both equations. (2 points)

(b) In a problem set, you explored how incidence would be modified when taxes might not be salient. A paper by Chetty, Kroft and Looney argues that consumers are less responsive to an excise tax that is calculated at the cash register than they are to a wholesale tax that is calculated upstream and included in the posted price of a good. In their setting, a lower response to taxes is welfare improving because it implies a smaller deadweight loss. Suppose that a planner was considering whether to impose a Pigouvian tax on a good that creates an externality, and they have a choice about whether to make the tax more or less salient by assessing it at the register or having it included in the purchase price.

- Intuitively, would you expect it to be socially efficient to include the Pigouvian tax in the posted price? On what does your answer depend? (2 points)
- How would you setup a model to describe this scenario? Specifically, try to write down the planner's problem and the consumer's problem to best capture this possibility. Explain the notation. Do not try to solve the problem. The goal here is simply to arrive at a setup. (2 points)

Question for ERE Field Exam, 2017

Question 2:

If you find yourself getting buried in algebra, describe the steps you would take to answer the question. For the optimization problem

$$\max_{\{c_\tau\}} \int_0^\infty e^{-\rho t}\left(c_t^\alpha - \frac{d}{2}x_t^2\right) dt$$

$$\text{s.t. } \frac{dx}{dt} = c - \delta x \quad x_0 \text{ given.}$$

(a) Write down the Hamiltonian and necessary conditions and use these to construct the phase portrait in (c, x) space.

(b) Obtain the comparative statics of the steady state with respect to ρ.

(c) Denote the optimal control rule as $c^*(x; \rho, \alpha, d)$. Is it possible to determine the sign of $\frac{\partial c^*(x;\rho,\alpha,d)}{\partial \rho}$? Explain.

(d) Write down the diffferential equation, $\frac{dc^*(x;\rho,\alpha,d)}{\partial x}$ whose solution is the optimal control rule.

(e) Sketch an algorithm for finding the numerical solution to the ODE in part (d).

Question 3:

ARE 264: Empirical Energy and Environmental Economics, Part 1

Exam - Spring 2017

1. [60 Percent] Suppose we are interested in measuring the effects of economic regulation and how it affects consumer and producer welfare through changes in profits and prices. We have located a dataset of plant-year observations for the entire United States that includes data on plant-specific output quantities and output prices. The data also include information on plant-specific input choices.

   The regulation requires cement and aluminum plants in California, Oregon, and Washington to install pollution abatement technologies before producing in the following year.

   (a) How would you use this data to estimate plant-specific marginal costs using estimates from a production function? Assume away industry entry/exit dynamics for the moment.

   (b) Let's assume that you have a dummy variable = 1 for plants affected by the regulation. We are interested in estimating the causal effect of this regulation on plant level costs and prices. What might be some issues associated with interpreting cross-sectional regressions of plant-level marginal costs on regulatory status as causal (e.g., comparing plants in regulated versus unregulated states)?

   (c) What might be some issues associated with interpreting time-series analysis of prices on regulatory status as causal (e.g., examining regulated industries over time before/after regulation)?

   (d) Let's suppose you decided upon a panel data research design, comparing regulated plants in regions before/after the regulation to plants in unregulated regions before/after. How would you use this variation to improve on the issues identified in items (a) and (b)? Specifically, write down a difference-in-differences regression model (using subscripts) and label variables (including controls).

      i. Describe in words the identifying assumption needed to have a causal interpretation of the main variable of interest in your difference in differences regression model. Formally show the identifying assumption (using expectations) and the notation of your regression model.

      ii. Usually it is not possible to explicitly test the identifying assumption, but researchers often present several indirect tests of the identifying assumption. Describe one indirect test of the identifying assumption and articulate why it is a useful test.

      iii. Aluminum production has relatively low transport costs while cement has relatively high transport costs. Both products lack product differentiation. Transport costs may affect the way in which these increases in marginal costs are passed through to consumers. Would you expect pass-through rates of this regional pollution regulation to be higher in aluminum or cement? Why?

2. [30 Percent] In class, we discussed several papers that explore the welfare effects of regulation using micro-founded models of a single industry. With knowledge (and/or assumptions) about consumer preferences and the industry supply curve, we can explore how different changes in marginal costs affect consumer and producer welfare. Describe one of these papers, articulating:

   (a) The primary research question of the paper.

   (b) The ways in which the researchers estimate / specify costs

   (c) One of the counterfactuals explored in the paper

3. [10 Percent] Compare and contrast the strengths/weaknesses of the empirical approaches in (1) versus (2).

Question 4: Experimental research designs, discrete choice models, and electricity demand

In one of the experimental papers we discussed (Information Frictions, Inertia, and Selection on Elasticity: A Field Experiment on Electricity Tariff Choice, by Ito et al.) the authors implement a recruit-and-deny design. They first recruit a sample of customers who express interest in a time-varying electricity pricing program. These willing participants are then randomly assigned to one of four groups:

- Z_0=1: Control group (denied!)
- Z_1=1: Customers have the option to switch to a time-varying electricity tariff.
- Z_2=1: Option to switch plus information about expected gains/losses on the new tariff (based on past electricity consumption).
- Z_3=1: Option to switch plus information plus monetary incentive. Customers receive \$60 if they switch to the new tariff.

The authors specify the following estimating equation:

$$lnx_{it} = \alpha_1 D_{1it} + \alpha_2 D_{2it} + \alpha_3 D_{3it} + \phi_i + \lambda_t + \eta_{it}, \quad (1)$$

where lnx_{it} is the natural log of electricity consumption at household i in hour t (measured pre and post-intervention), ϕ_i is a household fixed effect, λ_t is a time period fixed effect, the D_{kit} are binary variables indicating the *program participation status* of household i in time period t given treatment assignment k, $(k = control, 1, 2, 3)$.

Suppose this experiment had instead been implemented as a randomized encouragement design (RED). More precisely, suppose a random sample is drawn from the larger population of residential customers and this sample is randomly divided across the four groups described above.

(i) Suppose you regress lnx_{it} (observed for the entire RED sample) on time fixed effects, household fixed effects, and the set of treatment assignment indicators Z_{ij}. The α_k parameter estimates have a causal interpretation under some assumptions. What, precisely, are these assumptions? If these assumptions hold, what exactly is the causal interpretation of α_1?

(ii) Now suppose you estimate (1), but you instrument for the D_{kit} indicators using the corresponding treatment assignment indicators Z_{kit}. Using this IV approach, under what assumptions will the α_k parameters identify the local average treatment effect (LATE)? In this context, what exactly does the LATE estimate or capture?

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To complement this reduced form estimation, the authors make specific assumptions about the structure of consumers' utility functions and the discrete program participation choice. Given the structural assumptions imposed, the conditional indirect utility can be derived as a function of the vector of electricity prices associated with program j:

$$u_j^*(p_j;\theta,\epsilon) = -\sum_h \frac{\theta p_{jh}^{1+\epsilon_h}}{1+\epsilon_h} \tag{2}$$

ϵ is the price elasticity of demand for electricity and θ is a consumer-specific demand shifter. h indexes hours. Consumers enroll in the new pricing program (denoted $j = 1$) if switching to the time-varying rate yields a higher conditional indirect utility as compared to remaining on the standard rate structure. Different consumers face different information frictions ι and switching frictions/costs δ. The empirical specification of this discrete choice model implies that the consumer will switch if:

$$u_{i1}^*(p_1;\theta_i,\epsilon_i) - \iota_i \cdot Z_1 - (\delta_i - 60 \cdot Z_3) - u_{i0}^*(p_0;\theta_i,\epsilon_i) > \varepsilon_{i0} - \varepsilon_{i1} \tag{3}$$

This discrete choice model is implemented empirically as a mixed (a.k.a. random coefficients) logit. The price elasticity parameters, information frictions, and inertia parameters vary randomly in the population according to assumed distributions.

(iii) How can these authors leverage their experimental recruit-and-deny design, summarized in the first part of this question, to estimate the distributions of monetized ι and δ values in this discrete choice model?

(iv) These authors explore systematic heterogeneity in customer responses, both across experimental treatment groups and population sub-groups (e.g. structural winners/losers). In lecture, we discussed some important considerations when comparing treatment effect estimates across treatment groups in an experimental context, and choice parameter estimates across different types of agents and in a discrete choice framework. Briefly summarize these considerations, and comment on whether these concerns do/do not apply in this setting.