Environmental & Resource Field Exam

Wednesday, May $22^{nd}$

1:00pm-4:00pm

Room 275 University Hall

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

Good Luck!

Question 1: Question for ERE Field exam 2019

A price-taking sole-owner fishery chooses harvest to maximize the present discounted stream of profits over an infinite horizon. With harvest y, the endogenous price is p(y), and the harvest cost is c(x)y, where x is the stock. (Time subscripts suppressed.) The continuous discount rate is r>0. The growth equation is dx/dt =F(x) –y.

a) What is the relation between the solution to this problem and the solution to the problem of a planner who wants to maximize the present discounted value (PDV) of the flow of consumer surplus plus fishery profits? (Justify your answer in no more than a couple of sentences.)
b) Write down the Hamiltonian and the necessary conditions for optimality. Write down the conditions for the steady state.
c) Assuming that the steady state stock is interior, explain (mostly in words!) how you would determine the effect of the discount rate on the steady state.
d) For the special case where c(x) = c, a constant, write down the equation for the (assumed interior) steady state stock and provide the economic explanation of this equation.
e) Suppose that you had specific functional forms and parameter values. Using about 5 minutes, sketch one method of obtaining the numerical solution for the equilibrium harvest rule y*(x).

Question 2: **Qualifying Exam: Question from ARE 264, Module 1 Spring 2019**

For all parts, explain your answer using intuition, explanation and mathematics as you are able. **If you need to make additional assumptions/interpretations in order to answer a question, detail your assumptions or explain how they matter.**

(a) A good X is sold in two markets, A and B. The two markets are totally unrelated (quantities and prices in one do not affect demand or supply in the other). In both markets, consumption of X causes an externality of $\phi$ per unit sold. Demand for X is much more inelastic in Market A than it is in Market B. Supply conditions are the same in both markets.

**True or false:** if a planner sets a corrective tax on X in each market, the optimal tax in Market A should be lower than in Market B. Explain your answer. (3 points)

(b) **True or false:** A tax on emissions may not achieve the first-best outcome if the level of the tax is not set correctly, but such a tax is always more cost effective than a performance standard that achieves the same abatement. Explain your answer. (3 points)

(c) A homogenous good $x$ is demanded by a representative consumer with increasing and concave utility $U(x)$. The consumer has exogenous income, spent on $x$ and a quasi-linear numeraire. The good $x$ is produced by a perfectly competitive market of firms indexed by $j$ with increasing and convex production costs $c(x_j)$. The cost function is the same for each producer. Production of $x$ causes harmful emissions equal to $e_j = z_j x_j$, where $z_j$ varies across firms and is distributed uniformly between $[\underline{z}, \overline{z}]$, with all values of $z$ positive. Firms can abate emissions according to an abatement cost function $g(a)$, which is increasing and convex. "Net emissions" are $e_j - a_j$. Marginal damages from net emissions are uniform across firms and equal to $\phi$.

(i) **True or false:** In this setting, a corrective tax on the good $x$ is equivalent to a corrective tax on emissions $e$. (3 points)

(ii) Suppose that the government introduces a performance standard that puts a limit on the net emissions per unit of output at each plant that cannot be exceeded. Write down a generic firm $j$'s optimization problem that incorporates this policy. (2 points)

(iii) Thoroughly describe the efficiency properties of this policy as compared to a tax on emissions. (5 points) uestion 3: Consider the following equation:

(1) $Y_i = A_i K_i^{\beta} L_i^{\gamma}$

Here *i* indexes firms, *Y* measures their value of shipments (i.e., total sales), *A* is Hicks-neutral productivity, *K* is capital, and *L* is labor.

a. Consider a randomized controlled trial where some firms are randomly exposed to environmental regulation while others are not. How would you use this experiment in combination with equation (1) to measure the welfare consequences of the regulation? Does this identify all the parameters you need to undertake a full welfare evaluation of the regulation? If not, what is missing and what approaches could you use to identify it?

b. What is the economic interpretation of the coefficients $\beta$ and $\gamma$?

c. Suppose that for this analysis, you could replace equation (1) with another equation of your choice. What equation do you choose? What are its properties and assumptions? In what respects is it superior or inferior relative to equation (1)?

d. Imagine this is an analysis of the electricity generation industry. How if at all would your answer to part c change?

e. Discuss one empirical paper that uses a production function (equation 1 or any other functional form) to study an energy/environmental issue. How does the production function identify the main economic questions of interest? What are some of the strengths or weaknesses of this approach?

## Question 4: Discrete choice, hedonics, and 'partial' welfare analysis

This exam question is loosely based on the paper Ito and Shuang (2018). But the substance of the question (non-market valuation and partial welfare analysis within a discrete choice setting) draws on several of the papers and methods we discussed.

Consider a demand model for air purifiers that improve indoor air quality. Let $j$ denote the air purifier model/product. Let $i$ index the consumer. The latent utility that consumer $i$ derives from model $j$ is given by:

$$U_{ij} = \xi_j - \alpha p_j + \eta AQ_i \cdot Eff_j + \sum_k \beta_k' X_{jk} + \epsilon_{ij} \tag{1}$$

The price of product $j$ is $p_j$; air quality associated with consumer $i$ is $AQ_i$; $EFF_j$ denotes the efficiency with which purifier $j$ cleans the air; $X_{jk}$ are other observable attributes (indexed by $k$). $\xi_j$ is the structural error associated with model $j$.

Assume you observe market shares of the $J$ product models in $m$ different markets. Further assume you have valid instruments for both product price and air pollution (both of which are potentially endogenous).

### Part 1

Explain how you would use the conditional logit model, together with the Berry transformation (recall the transformation of the system of market share equations), to recover an estimate of the marginal willingness to pay (WTP) for air quality improvements. In your explanation, please be sure to elucidate the following:

- Intuitively explain/motivate a formulation of the average WTP for incremental air quality improvements expressed in terms of the parameters of the underlying latent utility function.
- Show how the Berry Transformation can be used to derive an OLS (or 2SLS) estimating equation. Hint: To get you started, recall the jumping off point is the system of market share equations - including the share claimed by the outside option.
- Highlight an assumption you must invoke in order to use these market-level data to construct an estimate of the average willingness to pay for an incremental improvement in air quality. (There are numerous assumptions - pick one that you see as important).

## Part 2

In Part 1, you derived an estimate for an average WTP. However, preference heterogeneity can have important implications for welfare analysis, distributional implications, and counterfactual predictions. We discussed how this discrete choice modeling framework can be extended to accommodate systematic preference heterogeneity. For example, we can allow preferences for air quality improvements to vary with observable demographic characteristics:

$$U_{ij} = \xi_j - \alpha p_j + \eta AQ_i \cdot Eff_j + \sum_k \beta_k' X_{jk} + \pi dem_i \cdot p_j + \epsilon_{ij} \tag{2}$$

For exam question simplicity, assume that the only demographic interaction is one between the product price and an indicator variable for post-secondary education level ($dem_i$ =0 for low education; 1 for high education).

(i) In lecture, we discussed some important identification considerations when comparing preference parameter estimates across different types of agents (e.g. more versus less fomal education) in this discrete choice framework. Briefly summarize these considerations. As part of your answer, please provide an intuitive interpretation of the parameter estimate $\pi$.

(ii) In Part 1, you explained how you could use your valid instruments to purge your Equation (1) parameter estimates of endogeneity-related bias. Under what conditions will this same strategy work in the context of Equation (2)? In other words, if you use the same instrumental variables strategy from Part 1 to estimate Equation (2), under what condition/assumption are you unconcerned about remaining endogeneity in the price x education interaction term?