WRITTEN PRELIMINARY Ph.D. EXAMINATION

Department of Applied Economics

Winter 2006

Natural Resource and Environmental Economics

Instructions:

- Identify yourself by your code letter, not your name, on each question.
- Start each question’s answer at the top of a new page.
- Answer four of the six questions, including at least one of the first two questions.
- You have four hours to complete this examination.
I. Two consumers of two goods, a composite market good \( x \) and a fixed environmental good \( q \), obtain utility according to the following functions: \( U^1(x,q) = \ln q + x \) and \( U^2(x,q) = xq \). Initially, the level of \( q \) is fixed at \( q_0 = 5 \). Each consumer has income of \( y = 20 \). Prices are \( p_x = p_q = 1 \). (The \( x \) good is numeraire and consumers must pay one dollar for each unit of \( q \) provided.)

A. Define the **compensating surplus** (CS) and **equivalent surplus** (ES) for a change from \( q_0 \) to \( q_1 \).

B. Calculate ES and CS for each consumer if the level of \( q \) increases from \( q_0 = 5 \) to \( q_1 = 10 \).

C. Using any argument that you wish, determine whether, in aggregate, a policy to increase \( q \) from 5 to 10 should be undertaken.

II. A researcher wishes to use contingent valuation to place a value on the preservation of a particular exurban wilderness area. She conducts a CV survey and obtains a set of data on individual characteristics (including income) and a yes-no response to the WTP question. The bid amounts vary from $5 to $100. The valuation model is specified using log-linear utility,

\[
v_i(y_j, z_j) + \varepsilon_{ij} = \beta \ln(y_j) + \alpha_i z_j + \varepsilon_{ij},
\]

and a logit distribution for the error term \( \varepsilon \). Probability of a yes response is

\[
\Pr(\text{yes}) = \Pr[v_i(y_j - t_j, z_j) + \varepsilon_{ij} > v_0(y_j, z_j) + \varepsilon_{ij}],
\]

In this specification, \( i = 1 \) denotes the state in which the proposed intervention is adopted and \( i = 0 \) the state in which it is not; \( j \) denotes the individual; and \( t_j \) is the bid amount.

A. The log-linear specification allows marginal utility of income to vary across individuals. Find an expression for marginal utility of income, based on equation (1).

B. Using the fact that if the individual responds yes, her realized income will be \( (y_j - t_j) \), write down a general expression for the probability of a yes response as it depends on composite income \( (y_j - t_j)/y_j \) and the vector \( z_j \) of explanatory variables. Also write down the specific expression for the probability of a yes response if \( \varepsilon_j \) is distributed logistically.

C. The researcher uses the survey data to estimate the following logit model:

\[
\Pr(\theta < (\alpha_0 + \alpha_1 \text{dist} + \alpha_2 \text{park} + \alpha_3 \text{age} + \alpha_4 \text{edu} - \beta \ln \left( \frac{y - t}{y} \right))/\sigma),
\]

where \( \theta \) represents WTP and the variable definitions, sample means, and parameter estimates are as follows.

<table>
<thead>
<tr>
<th>( \beta/\sigma )</th>
<th>Var defn</th>
<th>Sample mean</th>
<th>Parm est</th>
<th>Std error</th>
</tr>
</thead>
<tbody>
<tr>
<td>( \alpha_0/\sigma )</td>
<td>Composite income</td>
<td>47,500</td>
<td>2,765.2</td>
<td>834.5</td>
</tr>
<tr>
<td>( \alpha_1/\sigma )</td>
<td>Constant</td>
<td>—</td>
<td>1.54</td>
<td>0.61</td>
</tr>
<tr>
<td>( \alpha_2/\sigma )</td>
<td>Distance to area</td>
<td>3.25</td>
<td>-16.68</td>
<td>5.33</td>
</tr>
<tr>
<td>( \alpha_3/\sigma )</td>
<td>Visits park</td>
<td>0.42</td>
<td>1.79</td>
<td>1.24</td>
</tr>
<tr>
<td>( \alpha_4/\sigma )</td>
<td>Age of respondent</td>
<td>46.8</td>
<td>0.63</td>
<td>0.12</td>
</tr>
<tr>
<td>( \alpha_4/\sigma )</td>
<td>Education level</td>
<td>11.7</td>
<td>2.07</td>
<td>0.87</td>
</tr>
</tbody>
</table>

Willingness to pay is the income difference that equates the following two utility levels:

\[
\alpha_1 z_j + \beta \ln(y_j - \text{WTP}_j) + \varepsilon_{1j} = \alpha_0 z_j + \beta \ln(y_j) + \varepsilon_{0j}.
\]

Use this expression to solve for \( \text{WTP}_j \) and, using the fact that \( \varepsilon \) is distributed logistically (which means \( E(\varepsilon) = 0 \)), from the results in the table compute sample median WTP.
III. Suppose the inverse demand for an exhaustible resource is given by \( p(t) = q(t)^{-0.5} \), extraction costs are zero, initial reserve of the resource and discount rate are known, and there are no explorations for new reserves.

A. Solve for the time optimal path of extraction for the competitive mining industry, including the end time \( T \).

B. Solve for the time path of extraction for the monopolistic mining industry. How does it compare to that obtained for the competitive industry in part A?

C. What are the values for optimal end time for the monopoly and competitive industry, \( T_c \) and \( T_m \)?

D. How would the end time differ if the demand function was linear? Explain your reasoning.

IV. Suppose that a price-taking firm is extracting oil from an offshore platform and is subject to increasing costs as the stock of oil is depleted. At time \( t \) the firm’s profit is given by

\[
\pi = pq - cq^2 - cx,
\]

where \( p \), \( c \), and \( e \) are exogenous constants, \( q \) is the firm’s extraction rate, and \( x \) is the amount of the resource extracted to date. \( \pi \), \( q \), and \( x \) are all functions of time and \( x \) evolves according to the following equation:

\[
\dot{x} = q.
\]

Government regulations require the firm to remove the platform when oil extraction ceases. Removing the platform requires a lump-sum payment of \( D \) at the time the platform is removed. \( D \) is exogenous and does not depend on \( x \). The firm wants to maximize the present value of its profits taking into account that it will eventually have to pay \( D \). The interest rate is \( r \).

A. Set up the firm’s optimization problem and take first order conditions. Be sure not to forget about the terminal conditions.

B. Solve for the values of \( q(T) \) and \( x(T) \) at the time \( T \) that the firm shuts down the platform. How does \( x(T) \) compare to what the firm would choose if it didn’t have to pay \( D \)? Explain intuitively why this happens. Please discuss this as thoroughly as you can.

C. Solve for \( q(t) \) in terms of the exogenous variables and the ending time \( T \). Draw a graph of it.

D. Derive the equations of motion for the problem in \((q, x)\) space and draw an appropriate phase diagram showing the trajectory of the firm from the initial point to the terminal point. Be sure to label everything in the diagram.
V. A forest manager wants to know “When should we cut a stand of trees?” Assume that the land has no available alternative use, let \( Q(t) \) be volume of timber (i.e., board feet or cubic feet), \( P \) a constant price per pound of the crop, and \( r \) the constant interest rate. There are no harvesting costs.

A. Find the condition on the volume of timber that satisfies MSY (Maximum Sustainable Yield) of this forest. Write the optimization problem and derive the MSY condition.

B. Write the manager’s optimization problem of maximizing the present value of the forest stand. Derive the condition for optimal harvesting.

C. How does the rotation length of the MSY relate to the rotation length you found in section B? Why?

D. What will happen to the length of rotation in the following changes?
   1. A decrease in the price of timber.
   2. An increase in the interest rate.
   3. An increase in the harvesting cost.

   Analyze each change separately. Support your analysis with an explanation of the economic reasoning and formal changes in the harvesting condition.

VI. The recent jump in energy prices and oil in particular due to Katrina has been said to be a wakeup call for the U.S. To address this call, a number of recommendations have been suggested, including the following:

   i) The U.S. should ship goods by train instead of by trucks, get people to stop making long commutes, and have people eat locally produced goods instead of consuming produce from around the globe.

   ii) The U.S. government should raise energy standards for cars, SUVs, and light-duty trucks from 24 miles per gallon by 2011 to 36 miles per gallon by 2010.

   iii) The U.S. government should raise federal fuel taxes on all gasoline by 100%.

   iv) The U.S. government should provide subsidies to oil companies for oil exploration.

   v) The U.S. government should invest heavily in research to develop new energy resources.

   A. Discuss in economic terms how each of these alternatives might help reduce U.S. dependence on oil and whether or not they would actually significantly reduce U.S. oil dependence?

   B. Why change any aspects of U.S. energy policy of just increasing U.S. energy production? Explain why we can, or cannot, just let the private market provide the needed adjustments to address the rising and fluctuation price of oil.

   C. Conclude with your recommendation(s) concerning future U.S. energy policies regarding oil. Should the U.S. change it, and, if so, how?