Marine Resource Valuation and Optimization

Marine environmental and resource economics

- Marine pollution
- Resource management (e.g., fisheries and offshore oil)

Marine Resource Valuation

- Market
- Non-market

Optimization

- Social science model vs. Natural science model
- Decision maker -> Efficiency -> Optimization -> Control
- Similarities to engineering models (e.g., optimal control)

Outline of the talk

1. Valuation Techniques

2. What is optimization?

3. Mathematical Tools

4. Examples

- Coastal waste management
- Investment in pollution control technologies
- Environmental regulatory impact analysis

Application of Environmental Economics to Marine Policy Analysis

Economic framework organizes the information in ways which can be helpful to decision makers: examining social tradeoffs.

Economic analysis is required by law (e.g., CERCLA): Type A and Type B environmental damage assessment.

Costs increase rapidly with additional degree of remediation (e.g., PCB cleanup in Hudson River) -- How clean is clean?

Social objective is to maximizing social welfare:

$$\max \int_0^T [B(t) - C(t)]dt$$

Subject to budget constraints.

Social benefit (B): willingness to pay
Social cost (C): opportunity cost

B and C have two components:

Internal: market goods and services
e.g., dredging and disposal costs

External: non-market goods
e.g., values of public health, environment, and natural resources

Two Methods

1. Benefit-Cost Analysis

Good investment if benefit-cost ratio (B/C) > 1, or
Benefit (low end estimate) > cost (high end estimate)
Ranking options (other investment projects)

Limit: benefits are hard to quantify.

2. Cost-Effective Analysis

Assuming benefit is at least as large as cost (manager's judgement).

- Identify the least cost approach to achieve a given level of environmental improvement, or

- The maximum level of the improvement which can be achieved or a given cost.

Economic analysis should consider

1. Multiple options (including NO action): different technologies, levels of remediation.

2. Over time (long-term effects): the issue of discounting.

3. Multiple projects (sites): Hazardous Ranking System, National Priorities List (SARA).

4. Sensitivity analysis (uncertainty: natural and social sciences).

Quantification of Benefits and Costs

- Internal cost estimation is relatively easy: labor cost and equipment cost.

- External cost and benefit are extremely difficult to quantify (if possible).

Valuation Techniques

Natural Resources and the Environment

1. Revealed preference approaches

- Travel cost approach
  trip cost to a recreation site = value of the site

- Hedonic-price approach
  reduction in property values = environmental damage

2. Contingent valuation approach
   carefully designed survey: ask willingness to pay
   controversial estimates can be very high (non-use value)

Public Health Risks

1. Related market approach to value mortality risk
   e.g., behavior in choosing risky occupations

2. Human capital approach: earning potential

   Statistical life and cost per life saved

Optimization

<u>To identify the optimal strategy</u>

Maximization

- Social Net Benefit (B - C)
  Sustainable growth of a coastal economy

- Firm's Profit (R - C)
  Seafood company

- Individual Utility
  Coastal tourist

Minimization

- Social Cost
  Environmental damage from pollution

- Firm's Cost
  Environmental compliance

- Individual Expenditure

Duality

$$\text{Max } V = \text{Min } (-V)$$

Mathematical Tools

Static vs. Dynamic

Static
At equilibrium
- Introduction of pollution tax
- Adding a production facility

Dynamic
Time profile
- Fish stock recovery
- Growth of aquaculture industry

Deterministic vs. Stochastic

Stochastic factors:
- Fish population
- Weather condition
- Market price
- Regulatory changes

Real world problems are all stochastic and dynamic
- Must identify key variables and choose the right model
- The analytical power of a model do not necessarily increase with its complexity

Static

Unconstrained maximization

$$\max f(x)$$

$$\frac{\partial f(x^*)}{\partial x_i} = 0, \quad \text{for all } i$$

Constrained Maximization

$$\max f(x)$$

$$\text{subject to } g(x) = b$$

Dynamic

$$\max \int_0^T f[x(t), u(t)]dt$$

$$\text{subject to } \frac{dx}{dt} = g[x(t), u(t)]$$

x(t) is state variable

u(t) is control variable

Stochastic

$$\max E[f(x)]$$

Examples
(References)

- Optimal Waste Management in Coastal Communities

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- Environmental Regulatory Impact Anslysis

Jin, D. and T.A. Grigalunas, 1993. "Environmental Compliance and Energy Exploration and Production: Application to Offshore Oil and Gas." *Land Economics* 69(1):82-97.