Professional Career Program

Environmental Economic Theory No. 4

The basic analytical framework for policymakers' decision making

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Textbook: Barry .C. Field & Martha K. Fields (2009) ***Environmental Economics - an introduction***, McGraw-Hill, International Edition

PCP Environmental Economic Theory (Hosoda)
Homework 5
23 October 2018

1. Theme: Explain why future benefits and costs are discounted when the benefit-cost analysis is made? What is the justification for discounting?
2. Language: English.
3. Volume: A4 two pages. Single space. 12 points.
4. Submission period: 9 a.m. 29 October 2018~ 9 a.m. 30 October 2018.
5. Submission: Submit your paper in a pdf file. A file name must be "HW5.xxx.pdf" (xxx=your name). Send your file to hosoda@econ.keio.ac.jp.
6. Remark: Sources other than internet documents are recommendable. If you use internet information, check plural sources and compare them. List references you have used. References are indispensable.

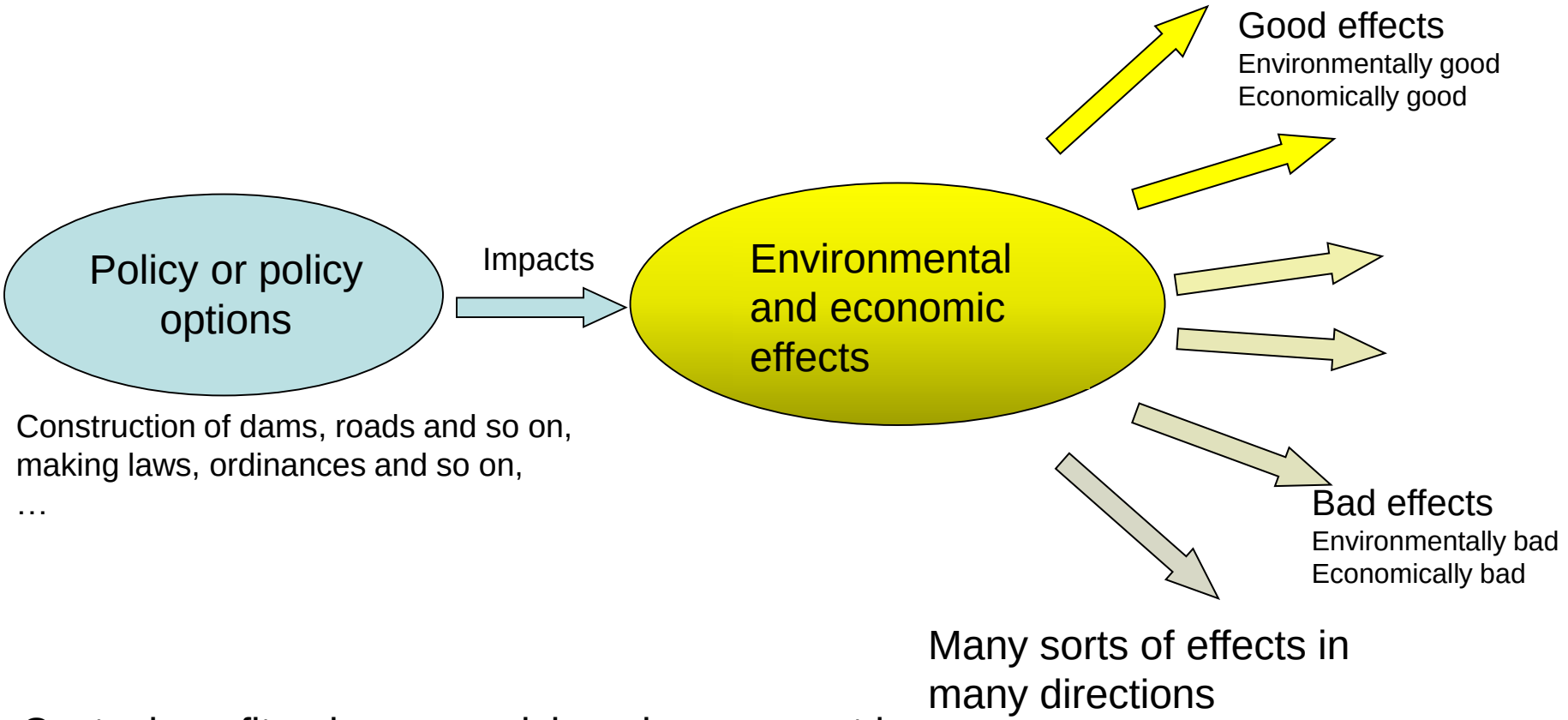
The purpose of this lecture

- Markets do not always promise socially desirable results from an environmental viewpoint, as you have already learned.
- Then, the environmental authority must do something to improve the situations, using regulation, taxation, introduction of permit-trading, and so on.
- The authority needs the analytical framework for environmental policy.
- Several alternative frameworks are examined.

Field of a policy analysis

- Thus, we are moving to the field of a policy analysis (a normative analysis) from a positive analysis in this lecture.
- The basic question is this: What *should* the government or authority do in order to lead an economy to a socially optimal position, taking environmental costs and benefits into account?
- *Review*: How is a socially optimal position defined?

Explanation by means of a figure



Costs, benefits, damages, risk and so on must be counted. Comparing plural policy options, we have to decide which option should be adopted to solve an environmental problem. But, *both* environmental and economic impacts must be taken into account.

Alternative frameworks to evaluate results

- Impact analysis: this consists of environmental impact analysis and economic impact analysis.
- Cost-effective analysis
- Damage assessment
- *Benefit-cost analysis* (the core element of this and the later lectures)
- Risk analysis

Which alternative should be adopted depends upon what type of policy option is considered.

1-1. Impact analysis

Environment impact analysis

- This analysis is the one which identifies all the significant effects on environment which come from a policy option.
- Environment impact analysis is required for construction, development and so on, which satisfy some conditions. (Public and private programs whose size is beyond a certain level.)
- It does not consider the social values.
- Not only ecological linkages but economic linkages are taken into account.

Remarks on the last point of p. 7

- “Thus, to study the full range of environmental impacts from the dam, it is necessary to include not just the physical effects of the dam and its water impoundment, but also the ways in which people will react and adapt to this new facility.” (Barry .C. Field & Martha K. Fields (2009) p. 113.)

Remarks on the last point of p. 7 (cont.)

- However, it is really a tough work to count all the physical effects of the dam and its water impoundment, and take into account all the ways in which people will react and adapt to this new facility.

1-2. Impact analysis

Economic impact analysis

- People, businessmen, and the central government as well as the local governments are often concerned with the economic effects of environmental regulations.
- This is because some environmental regulations give serious impacts to economic growth (e.g., carbon tax!).
- These impacts *often* (not always) mean lowering an economic growth rate and thus increasing economic costs.
- Hence, the benefit-cost comparison is required.

A remark on an economic impact analysis

- Economic impact analyses can be focused at any level.
- A local level: Eg. The impact of a wetlands law on the population growth rate and tax base in the economy.
- Regional level: The impact of a national regulation on regional ecologic circumstances.
- Global level: The impact of CO2 emission control on the relative growth rates of rich and poor countries.

1-3. Impact analysis
Regulatory impact analysis

- Regulatory impact analysis is the one which identifies the impacts of regulatory measures on an economy and environment.
- This analysis is required in quite a few countries when the authorities are planning some programs which are supposed to give impacts to an economy and environment.
- By means of this analysis, policies may be evaluated before implementation, and reviewed after implementation.

A remark

- Japanese government has introduced a policy impact analysis, which is similar to regulatory impact analysis.
- Almost all the policies adopted by the government must be reviewed by neutral persons, and it is checked how those policies are effective or not.

2-1. Cost-effective analysis

- The cost-effective analysis is the one which estimates the costs of different alternatives which aim to meet the *given target*. (The objective is given.)
- See Table 6.1 in the textbook. The option "replace movie-industry" is the cheapest alternative, which should be adopted.
- The cost-effective criterion is deeply connected with the efficiency one, although not the same.
- How the amount of some pollutants should be reduced depends upon marginal abatement costs.

2-2. Cost-effective analysis

- Equi-marginal principle is the criterion for social efficiency problems. (If you don’t understand this, please review the former lecture slides)
- This principle, however, needs the information about costs of the alternatives.
- Cost-effectiveness is a necessary condition for the social efficiency, but not a sufficient condition.
- Cost-effectiveness gives us rough information on how desirable a policy option be.

3. Damage assessment

- Damage assessment aims to estimate the value of damages which a certain policy option might cause, or the amount of money which is required to restore the resources to the original state.
- Nowadays in U.S.A, restoration cost is preferred to lost resource cost as a measure of damages.
- There are some problems with this assessment. For example, it is hard to determine what the original state is.

Trees are dying of acid rain.

Is restoration possible?

- It may be very costly or almost impossible to restore those trees which died due to acid rain.
- In that case, the restoration costs may possibly be huge or even infinite.

4-1. Benefit-cost analysis

- The purpose of this analysis is to compare expected revenues with anticipated costs for some public programs.
- This analysis is usually adopted when we have to measure the values which are not counted in markets.
- The principle of this analysis is as follows: if the aggregate value of benefits, to whomever they accrue, are larger than estimated costs, then the proposed project or program *should* be adopted.

4-2. Benefit-cost analysis

- There are supporters for this analysis as well as opponents.
- Supporters argue that this method is appropriate for judging public programs or projects which might affect environment.
- Opponents argue that benefits are hard to measure (sometimes costs too), and the method often gives biased results toward development.
- Yet, this approach has been adopted in many countries.
- There is no proper alternative to this analysis.

4-3-1. Benefit-cost analysis

- The basic procedure of the analysis is as follows:

(1) Specify the project or program. Also, define the environmental, economic, and geographic domain.

(2) Specify the inputs required and the outputs which are supposed to be obtained.

(3) Estimate the social costs and benefits of the inputs and outputs in the domain.

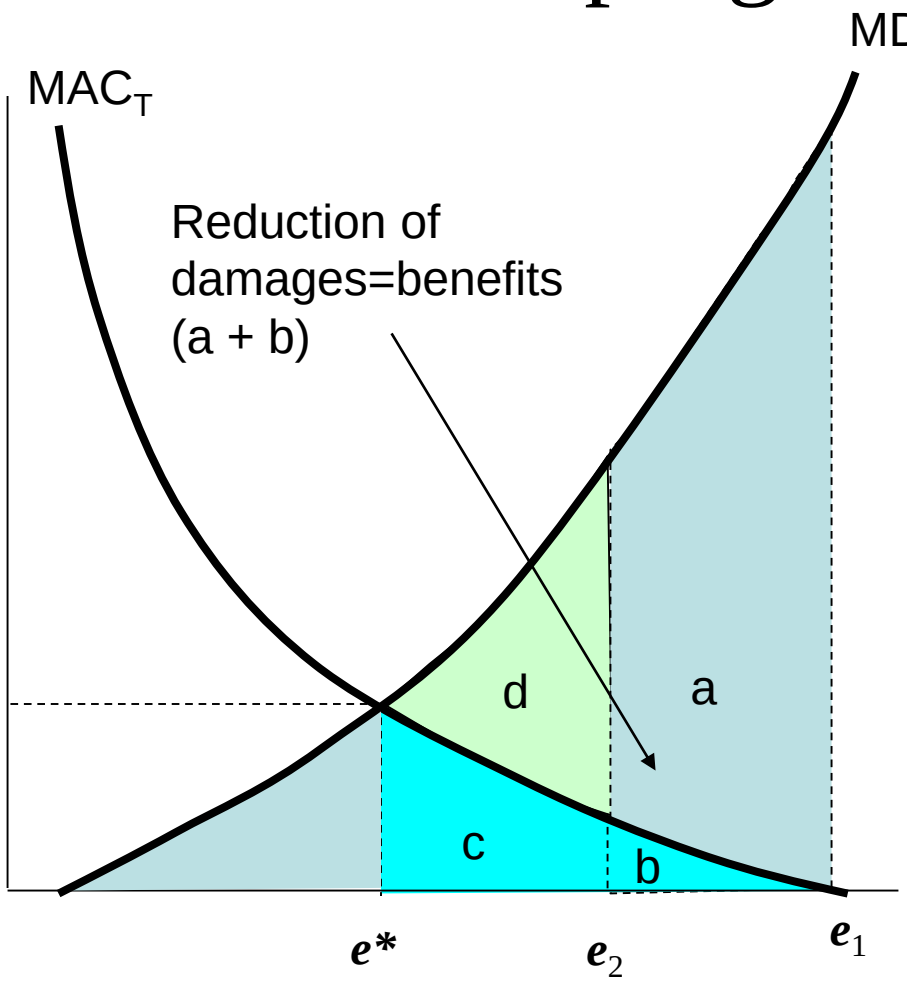
(4) Compare these benefits and costs.

See the details in pp. 119-122 of the textbook (The Basic Framework and Scope of the Program).

4-3-2. Benefit-cost analysis

- The basic formula of the analysis is as follows:
- Measure the stream of the future costs $\boldsymbol{C_i}$ (i = 0, 1, 2, … $\boldsymbol{T}$).
- Also, measure the stream of the future benefits $\boldsymbol{B_i}$ (i = 0, 1, 2, … $\boldsymbol{T}$).
- Calculate $\sum_{\boldsymbol{i}=0}^{\boldsymbol{T}} (\boldsymbol{B_i} - \boldsymbol{C_i})/(1 + \boldsymbol{r})^{\boldsymbol{i}}$.
- If it is positive, perform the project. If not, give it up.

4-4. The appropriate scope of the program



The efficient level of the emission is e^*. Yet, the program may require the reduction to e_2 from e_1. The scope of the program is smaller than the socially desirable one.

At the emission level e^*, the social costs are minimized. But the benefit-cost ratio may be higher at e_2 than at the socially desirable point, so that the ratio may be a misleading indicator as the one for the appropriate scope.

Sensitivity analysis is required to determine the appropriate scope.

A note: sensitivity analysis

- A sensitivity analysis is a technique used to determine how different values of an independent variable impact a particular dependent variable under a given set of assumptions. This technique is used within specific boundaries that depend on one or more input variables, such as the effect that changes in interest rates have on bond prices.

(Source: Investopedia)

4-5-1. What does discounting mean?

- If $\sum_{i=0}^{T} \boldsymbol{B_i} /(1+\boldsymbol{r})^{\boldsymbol{i}} / \sum_{i=0}^{T} \boldsymbol{C_i} /(1+\boldsymbol{r})^{\boldsymbol{i}} > 1$, then the project should be performed.
- But why should we discount the future benefits and costs?
- The higher the discount rate, the lower the present value of any future benefits or costs.
- Thus, the time profiles of costs and benefits of projects become very important for determining the discounted sum of the streams' value.

4-5-2. What does discounting mean?

- There are mainly two reasons for discounting: one reason is that we have ***time preference***. The other is that investment creates ***surplus***.
- Whichever reason might be adopted, it is natural to suppose that we have a propensity to discount future benefits and costs.
- Unless discounting is adopted, the discounted sum of the future stream may not be obtained when the time span of the project is infinity.

4-5-3a. What is time preference?

- We cannot live forever. Who cares about the long-distant future, in which you may be in heaven?
- Even in the our life-time span, we give more weight to the present than future because the future is uncertain.
- Even if we could live forever and there should be no uncertainty, we give more weight to the present than the future because we are irrational!

4-5-3b. Why surplus is obtained by investment?

- We can gain more by round-about production than we can gain by using resources now.
- Thus, investment produces surplus and can get the return back to the investor.
- If there is no financial intermediary (banks and so on), the rate of time preference and the rate of return should be equal to each other.
- But, the consumers' lending rate is smaller than the firms' borrowing rate since there is financial intermediary.

4-5-4. What rate should be adopted as the appropriate discount rate?

- There are many rates of interests or return for a candidate of the appropriate discount rate.
- The rate of interest of a long-term bond may be appropriate as the discount rate.
- The prime rate of the loan for big companies may be appropriate for the rate.
- There is no unanimous opinion on which rate should be adopted as a discount rate.

4-6. Some problems on discounting

- Is it really legitimate to discount future benefits and costs?
- Some people insist that the appropriate discount rate should be zero for long-run environmental projects.
- If a high discount rate is applied, environmentally devastating projects tend to be adopted, since environmental costs often appear in future.
- How can we reconcile the present generation's benefits with the future generation's one?
- It is not so easy to answer this question.

Discussion

- Future generation cannot say anything on projects which are carried now, even though environmental costs are born by the future generations.
- There is no dialogue possible between present and future generations.
- But, the present generation is responsible for long-run effects of the action which they take now, aren’t they?

4-7-1. Distribution problems (a)

- Even if the appropriate discount rate is found and chosen, there is another problem on a benefit-cost analysis.
- Benefits and costs are distributed among many actors, some of whom are winner and others are loser.
- It is hard to have a win-win solution for everyone.
- A cost-benefit analysis does not tell anything about problems related to equity.

4-7-2. Distribution problems (b)

- There are two types of equity; horizontal equity and vertical equity.
- Horizontal equity is concerned with income (wealth) distribution among the present generation.
- Vertical equity is concerned with income (wealth) distribution between the present and future generations.
- It is hard to estimate the distributional impacts of environmental programs.

4-7-3. Distribution problems (c)

- Benefits and costs are unevenly distributed among many actors.
- Costs are sometimes born by poor people, while benefits are obtained by rich people.
- This often happens in pollution problems.
- Costs are sometimes born by the future generation, while benefits are obtained by the present generation.
- Isn’t this unfair?

5. Risk analysis

- Basically risk analysis consists of

(1) risk assessment: examination of the risk nature and human behavior, and measurement of risk factors,

(2) risk valuation: valuation of reduction of the risk factors.

(3) risk management: to examine how to avoid the risk and what method should be adopted.

5-1. Risk assessment

- Basically risk assessment consists of

(1) exposure analysis: to examine how much people are exposed to risk factors.

(2) does-response analysis: to determine the relationship between the exposure and incidence of illness.

(3) risk characterization: to estimate the specific risks faced by people.

5-2-1. Risk valuation

- As for some risks, economic valuation is required.
- Although risk can be assessed by scientists, valuation of risks falls in the field of economists.
- If a probability distribution is known and the damage is expressed by monetary unit, then the expected value of the risk can be calculated.

5-2-2. Risk valuation

- Probability distributions of some risks are obtained as the normal distribution, the binominal distribution and so on.
- Some damages may be expressed in monetary terms.
- Then, the expected value of the risk is obtained as $\Sigma \boldsymbol{p}(\boldsymbol{x}_i)\, \boldsymbol{x}_i$ where $\boldsymbol{x}_i$ is the monetary loss due to the damage caused by the $\boldsymbol{i}$-th phenomenon of the risk, and $\boldsymbol{p}(\boldsymbol{x}_i)$ is its probability.

5-2-3. Risk valuation

- People may disagree with the calculated risk valuation.
- Some people take a certain type of risks more seriously than other types even if the expected value is the same.
- Scientific risk valuation often differs from ordinary people’s sense of risks.
- Thus, many people are still smoking.

5-2-4. Risk valuation

- Some people take a risk neutral attitude: they regard the risks which have the same expected value as indifferent.
- Other people take a risk averse attitude: they consider the risk whose variance is larger than the alternative risk's variance more risky.
- Many people take a risk averse attitude toward some environmental problems such as global warming, groundwater pollution and so on.

5-3-1. Risk management

- Policymakers decide what they should do to avoid risks or lower a risk probability.
- The risk-benefit analysis is a tool for policymakers' decision making.
- But they have to compare the results of a risk with the benefits obtained from the risk avoidance.
- This comparison looks similar to that of the benefit-cost analysis.

5-3-2. Risk management

- Yet, risk is *not* the same as costs.
- Risks are often difficult to measure. We cannot compare the risk of cancer with that of athlete's foot.
- Sometimes life-extension is chosen as the index of benefits.
- Some experts are considering Quality of Life (QOL), instead of life-extension, as the end-point of the risk analysis.
- Yet, it is often difficult to measure QOL.

A note on QOL

- QOL is a concept which expresses real happiness of each individual's life. It is concerned with how each individual is sending a satisfactory human life.
- Yet, it is not easy to precisely define QOL and make an index for QOL.