Cost Benefit Analysis

Background of Cost-Benefit Analysis

- The idea of this economic accounting originated with Jules Dupuit, a French civil engineer
  - The optimum toll for a bridge (1844)

- Cost–benefit analysis is often used by governments to evaluate the desirability of a given policy intervention.
  - Strict budget constraint of governments
  - To show necessity and effectiveness of public projects
  - To ensure the accountability to taxpayers

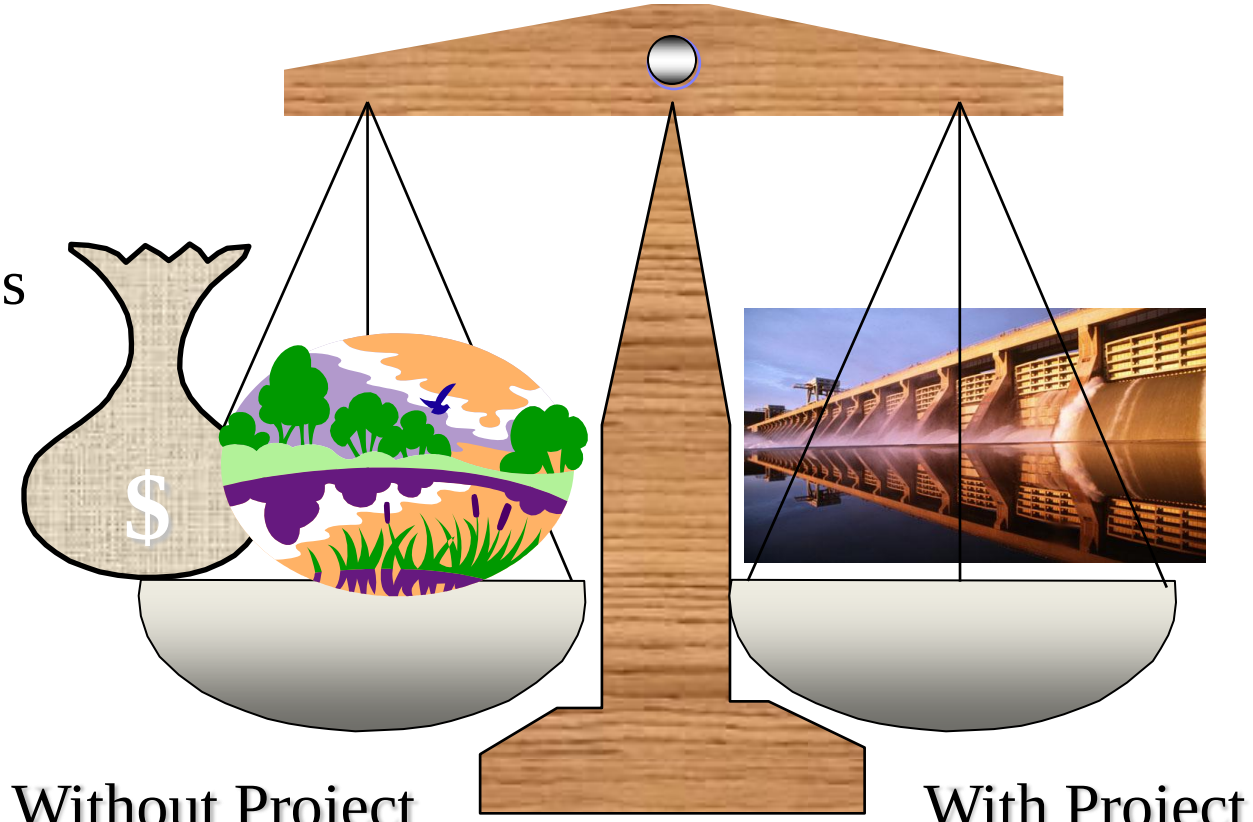
Cost-Benefit Analysis

- Financial Analysis
  - The private profit (a time-series cash flow) is only considered

- Cost-benefit analysis
  - includes tangible/intangible effects to the economy
  - takes into account of externalities such as pollutions to third persons/groups or environmental damages
  - considers

With-without Principle

Willingness to pay



Without Project

With Project

The main steps of Cost-Benefit Analysis

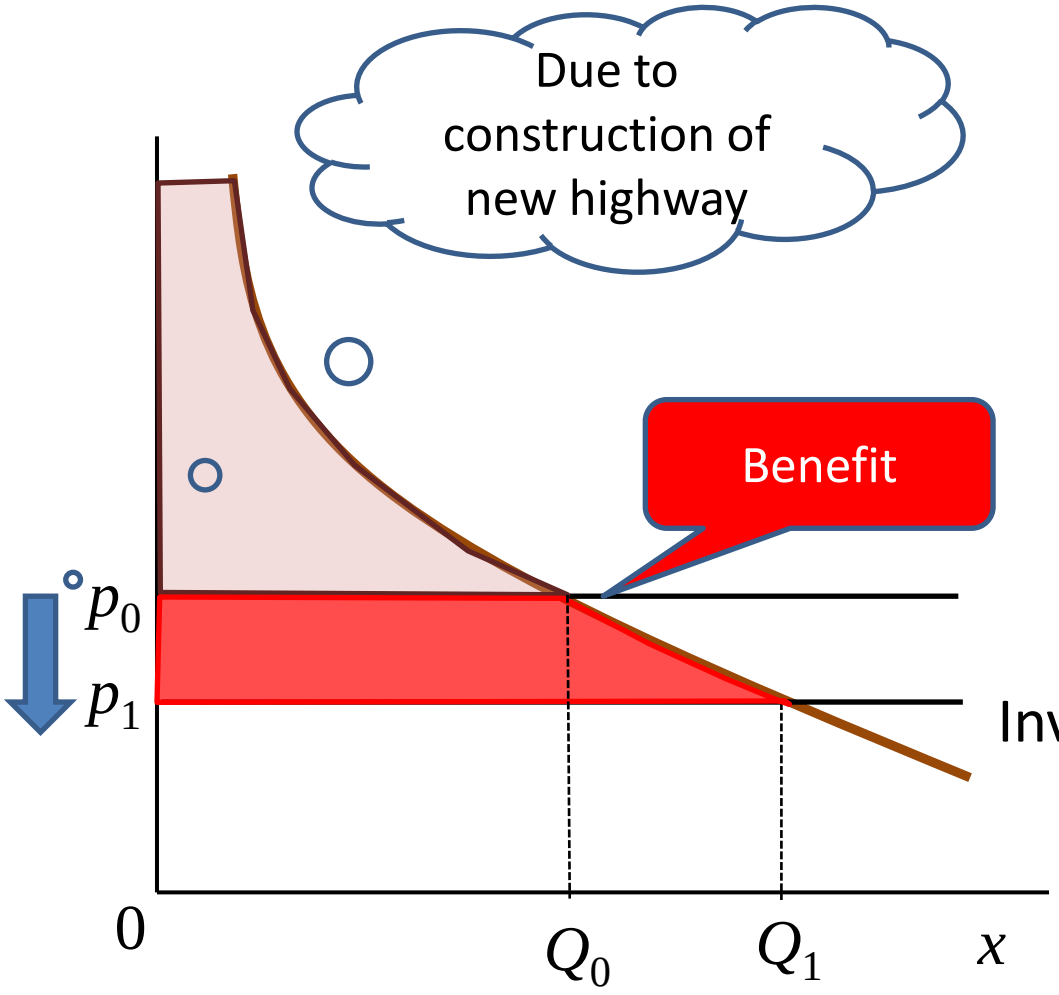
1. Listing items of cost/benefit for public projects?
2. Measurement and forecasting of time-series cost/benefit
3. Comparison in terms of cost/benefit between projects
4. Selection of a project

The procedure of Cost-Benefit Analysis

- The benefit of consumers from the project is evaluated as consumer surplus

- Consumer surplus is the difference between the maximum price a consumer is willing to pay and the actual price they do pay.

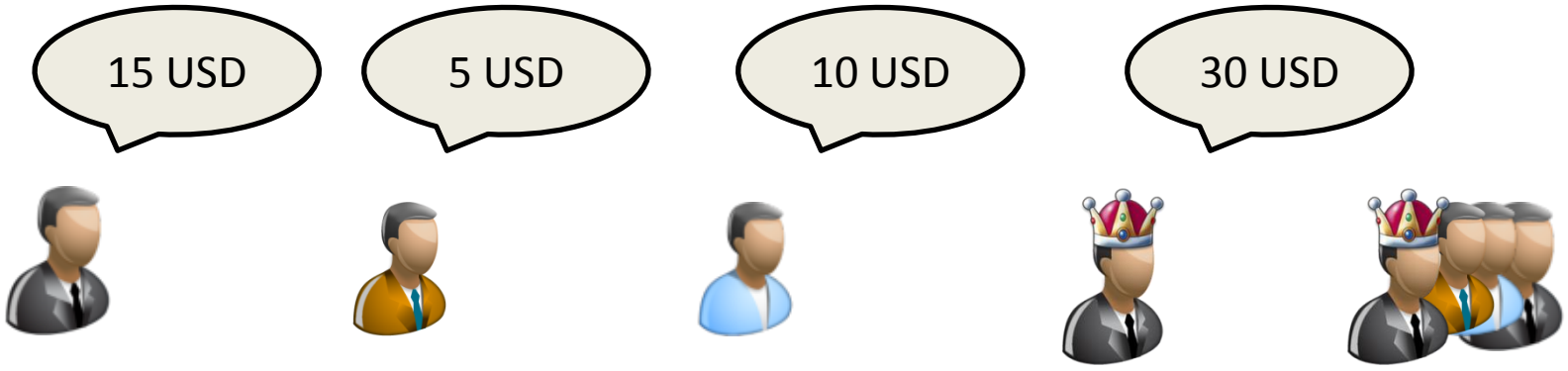
Definition of Benefit



Inverse of Demand Function

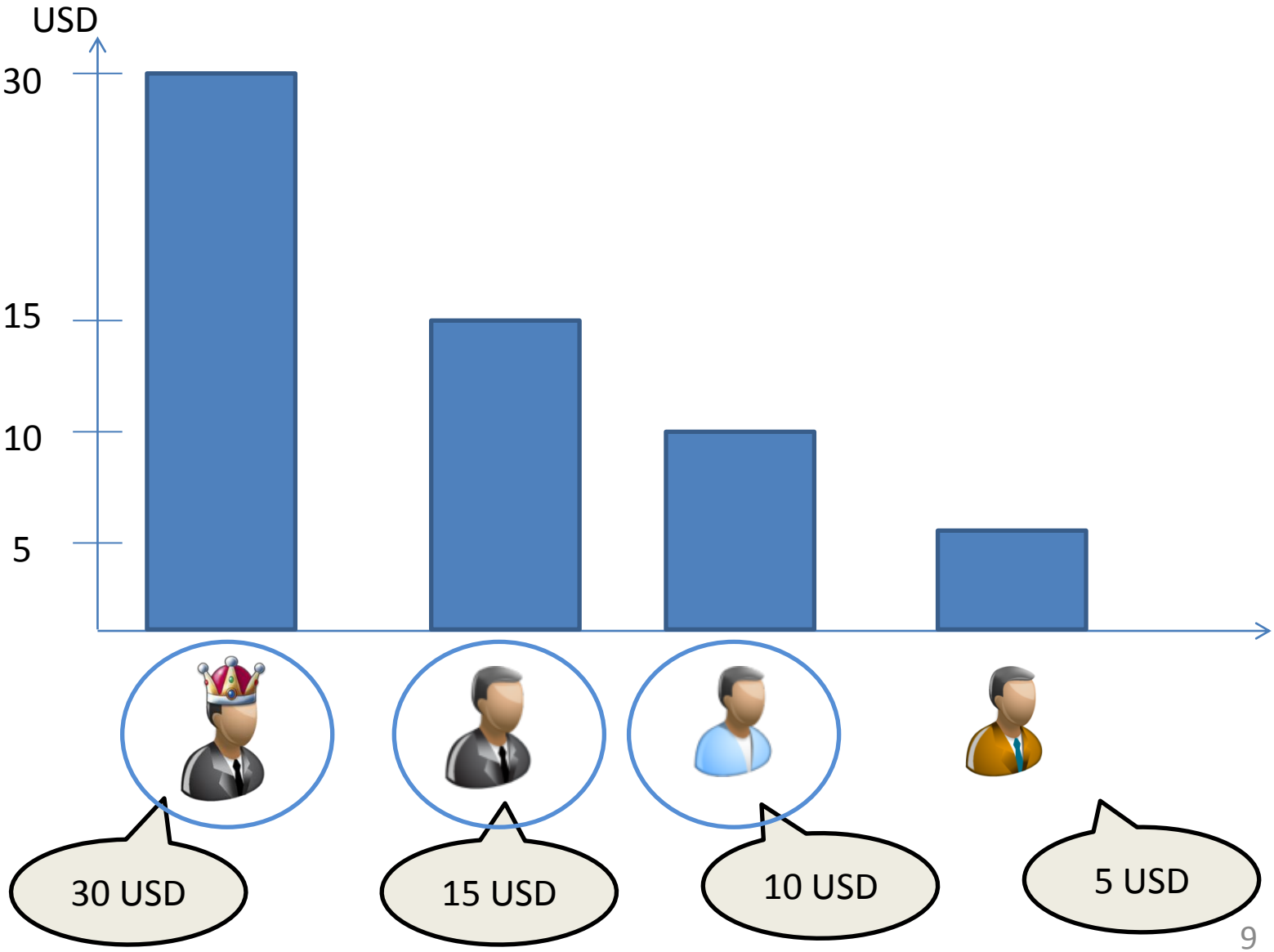
Willingness to Pay

- Ex. A new highway project
  - How much is the maximum amount of money you willing to pay when you use this highway ?

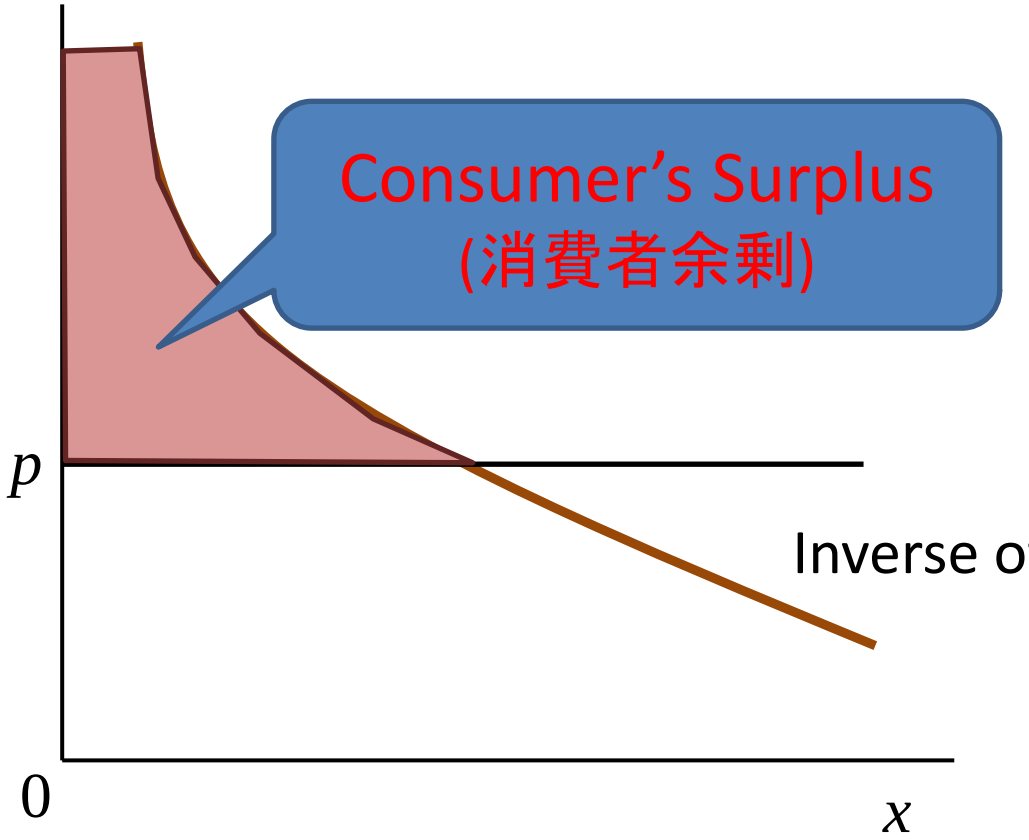


Each household has a different willingness to pay to use the highway

Consumer Surplus

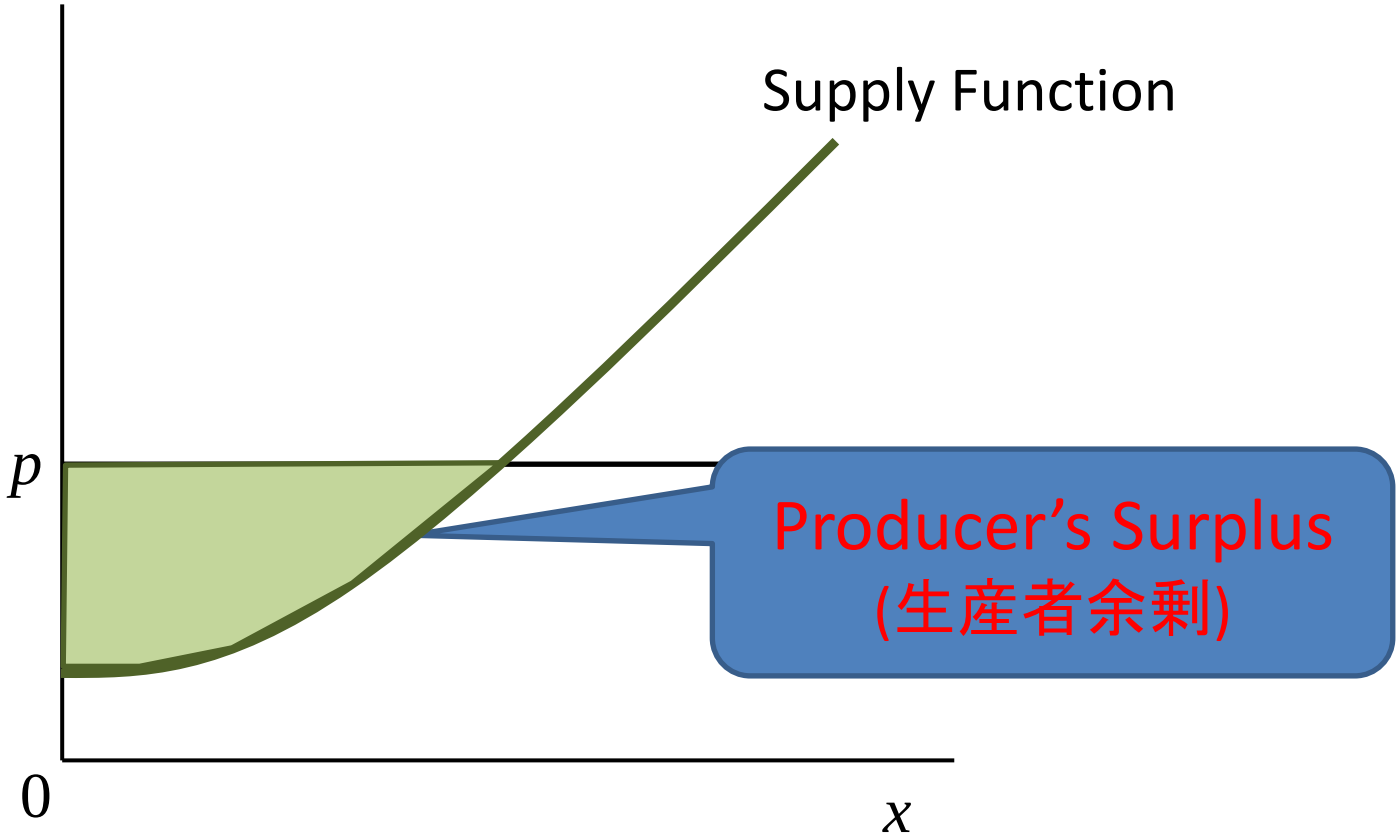


Consumer's Surplus
(消費者余剰)

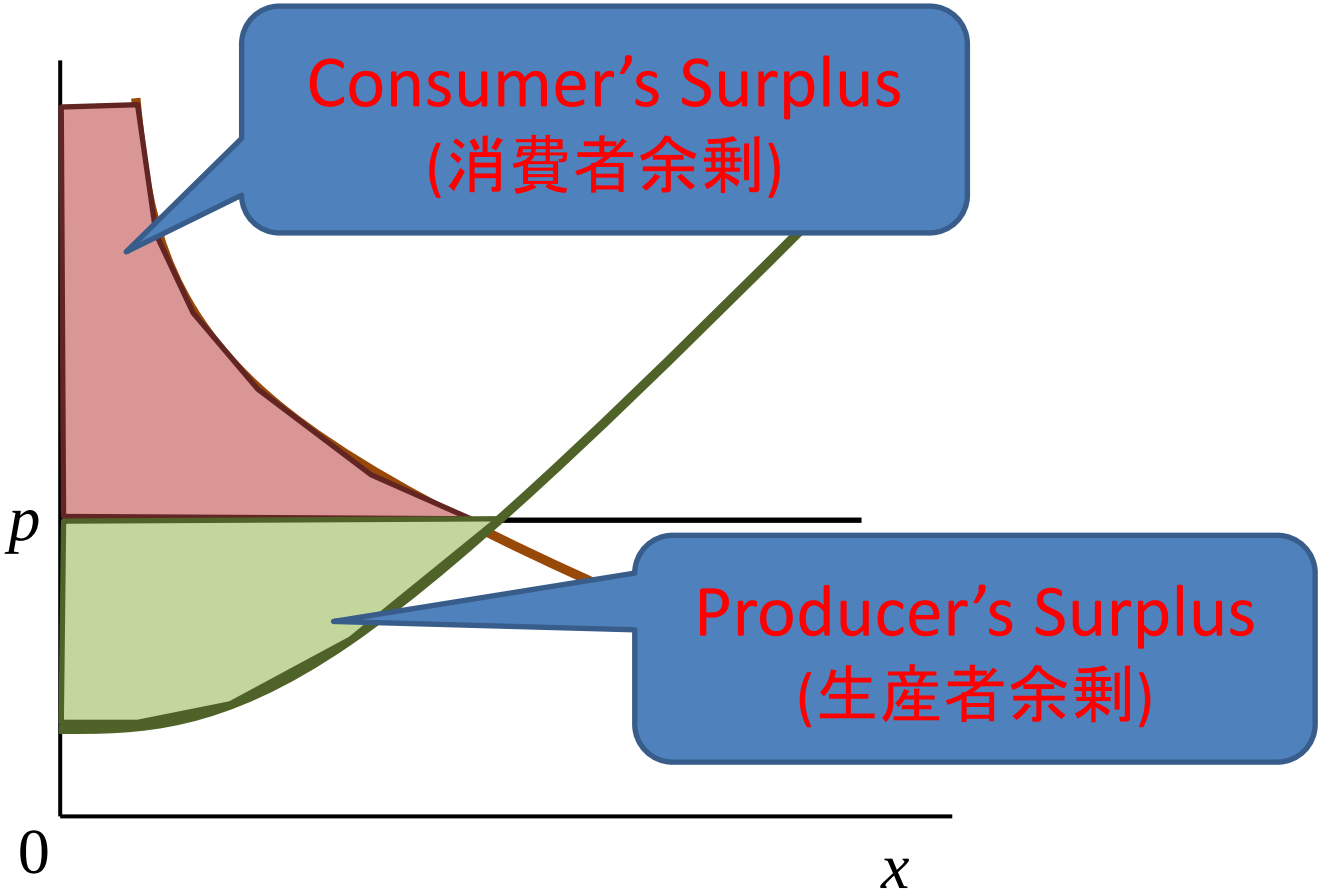


Inverse of Demand Function

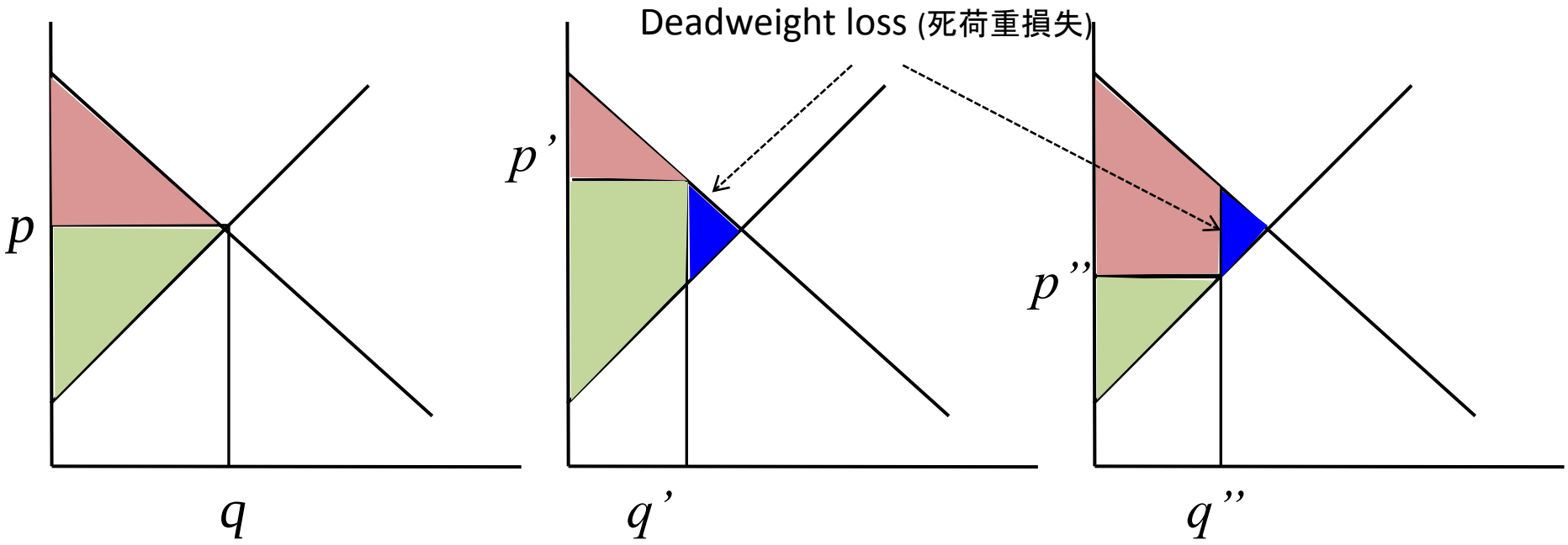
Producer's Surplus
(生産者余剰)



Social Surplus
(社会的余剰)



Efficiency at Pure Competitive Market



Pure Competitive Market

Other case (1); allocation

Other case (2); price control

- Efficiency is measured by Social Surplus

Cost and Benefit (1)

- In general, the duration of construction project is long . Therefore, let us consider nth year project
  - Cost : $c_1, c_2, \ldots, c_n$
  - Benefit : $b_1, b_2, \ldots, b_n$
- The future's value is converted into the present value using **discount rate** r
  - It is assumed that the value of 10,000 yen one year's later is lower than that of now
- The present value of c_t and b_t
  - Present value of $c_t = c_t / (1+r)^{t-1}$
  - Present value of $b_t = b_t / (1+r)^{t-1}$

Cost and Benefit (2)

- The summation of present value of cost or benefit is respectively defined as;

$$C = \sum_{t=1}^{n} \frac{c_t}{(1+r)^{t-1}}$$

$$B = \sum_{t=1}^{n} \frac{b_t}{(1+r)^{t-1}}$$

Criteria for CBA

1. **Net Present Value** (NPV; 純現在価値）

$$NPV = B - C = \sum_{t=1}^{n} \frac{b_t - c_t}{(1+r)^{t-1}}$$

2. **Cost Benefit Ratio** (CBR; 費用便益比)

$$CBR = \frac{B}{C} = \sum_{t=1}^{n} \frac{b_t}{(1+r)^{t-1}} \Big/ \sum_{t=1}^{n} \frac{c_t}{(1+r)^{t-1}}$$

3. **Internal Ratio of Return** (IRR; 内部収益率）

$$IRR = r^* \ \ where \sum_{t=1}^{n} \frac{b_t - c_t}{(1+r^*)^{t-1}} = 0$$

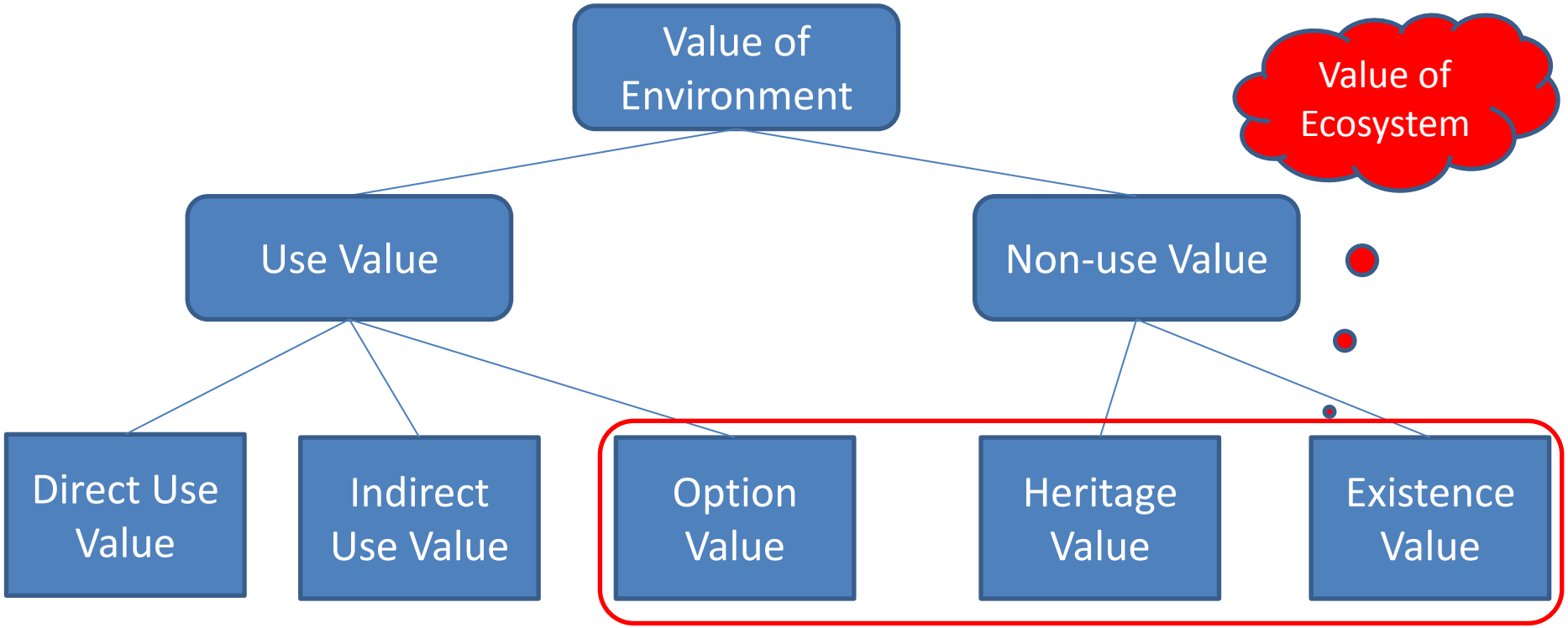
Comparison of three criteria

Criteria	Condition that a project is adopted	Feature
NPV	$NPV \geq 0$	**NPV** is applied when a decision maker, without considering a budget constraints, wants to adopt a project with bigger effect
CBR	$CBR \geq 1$	**CBR** is applied when a decision maker, with considering a budget constraints, wants to adopt an effective project
IRR	IRR is **greater** than a certain threshold	**IRR** is applied when a decision maker highly consider the profitability

Evaluation of the benefit of **Ecosystem**

- So far, it is assumed that the benefit is evaluated with the **monetary value**
- It is impossible to evaluate the benefit of ecosystem with the monetary value
  - Value of park, wild animal, …
- **However**, if we cannot evaluate the value of them, it is difficult to preserve them.

Function of Ecosystem from the viewpoint of Utility Forms



How to evaluate the value of Ecosystem ?

- **Based on Revealed Preference (RP)**

  ➔ The value is evaluated based on the statistical data

  – **Travel Cost method**
    - The value of recreation is evaluated based on travel cost

  – **Hedonic approach**
    - The value of environmental resource is evaluated based on it's effect to the land price and the wages

- **Based on Stated Preference (SP)**

  ➔ The value is evaluated by directly asking to people

  – **Contingent Value Method (CVM)**

CVM (Contingent Value Method)

- The contingent valuation method (CVM) is the methodology to ask households' willingness to pay by asking them contingent situation where the environment becomes better (or worse)
- It is widely used to evaluate non-market value

Outline of CVM

- The value of ecosystem is evaluated based on questionnaire
  Example of questionnaire
  - How much will you pay if you preserve the scenery against constructing a tall building?
  - LRT can contribute to eco-friendly city and to create good scenery. How much will you pay to introduce LRT system?

Random Utility Model by Hanemann(1984)

"Suppose that the tax will increase ¥T/year in order to change the quality level of the environment from Q' to Q". Do you agree with the policy?

$$V(Q'', C, M - T)$$
$$V(Q', C, M)$$

C:households' attribute

$$\Pr(Yes)$$
$$= \Pr[V(Q'', C, M - T) + \varepsilon'' \geq V(Q', C, M) + \varepsilon']$$
$$= \Pr[\Delta V + \eta \geq 0]$$
$$1 - Gn(-\Delta V)$$

If *Gn* follows the logistic distribution,

$$\Pr(Yes) = \frac{1}{1 + e^{-\Delta V}}$$

Median $\Pr(Yes) = 0.5$

$\Leftrightarrow$

$\Delta V = 0$

$\Leftrightarrow$

$$V(Q'', C, M - CS) = V(Q', C, M)$$

Mean value $E[CS] = \int_0^{\infty} [1 - G_n(t)]dt$

The probability where households answer ‘Yes’