EE441 Economics of Public Expenditure

8. Cost-Benefit Analysis

Euamporn Phijaisanit
Faculty of Economics
Thammasat University
1/2017

Outline of Topic 8

1. Present Value
   a. Projecting present dollars into the future
   b. Projecting future dollars into the present
   c. Inflation
2. Private Sector Project Evaluation
   a. Internal rate of returns
   b. Benefit-cost ratio
3. Discount Rate for Government Projects
   a. Rates based on returns in the private sector
   b. Social discount rate
   c. Discounting and the economics of climate change
   d. Government discounting in practice
4. Valuing Public Benefits and Costs
   a. Market prices
   b. Adjusted market prices
   c. Consumer surplus
   d. Inferences from economic behavior
   e. Valuing intangibles

Outline of Topic 8

5. Game Cost-Benefit Analysts Play
   a. The chain-reaction game
   b. The labor game
   c. The double-counting game
6. Distributional Considerations
7. Uncertainty
8. An application: Are reductions in class size worth it?
   a. Discount rate
   b. Costs
   c. Benefits
   d. The bottom line and evaluation
9. Use (and Nonuse) by Government

Cost-Benefit Analysis

- A set of systematic procedures based on welfare economics for guiding public expenditure decision.
- CBA allows policymakers to attempt to do what well-functioning markets do automatically- allocate resources to a project as long as the marginal social benefit exceeds the marginal social cost.

Present Value & Discount Rate

- Present Value (R)-The value today of a given amount of money to be paid or received in the future.
- Discount rate (r) - the rate of interest used to compute present value.

Projecting Present Dollars into the Future

R=$ T=years r=interest rate

How much will $1000 earn in 3 years at an interest rate of 10%?

$R_0 = \$1000$

$R_1 = \$1000*(1+.10) = \$1100$

$R_2 = \$1100*(1+.10) = \$1210$

$R_3 = \$1210*(1+.10) = \$1331$

$$\mathbf{R_T = R_0*(1+r)^T}$$

Projecting Future Dollars into the Present

How much will $1,000 earned in 2 years at an interest rate of 10% be worth today?

Since $R_T = R_0*(1+r)^T$

Present Value $R_0 = R_T/(1+r)^T$

discount factor

discount rate

Low *r* – more future-oriented and benefits projects in which returns are concentrated further into the future

High *r* – more present-oriented and benefits projects in which returns are concentrated closer into the future

Note: The longer you have to wait for a sum to be paid, the less you are willing to pay for it today, other things being the same.

Present Value of a Stream of Money

$$PV = R_0 + \frac{R_1}{(1+r)} + \frac{R_2}{(1+r)^2} + \ldots + \frac{R_T}{(1+r)^T}$$

Inflation

- Nominal amounts- amounts of money that are valued according to the price levels that exist in the years that the amounts are received.
- Real amounts- Amounts of money adjusted for changes in the general price level.

Inflation

How to incorporate inflation – price level increases – into the procedure?

Given: $\prod$ = inflation rate

$$PV = R_0 + \frac{(1+\Pi)R_1}{(1+\Pi)(1+r)} + \frac{(1+\Pi)^2 R_2}{(1+\Pi)^2(1+r)^2} + \ldots + \frac{(1+\Pi)^T R_T}{(1+\Pi)^T(1+r)^T}$$

However, (1+$\prod$) terms cancel out, leaving the PV equation from previous slide!

CAUTION: $ values and r values must be measured consistently – if real values are used for *R*, the *r* must be measured in real terms

Private Sector Project Evaluation

- Rules for evaluating projects stating that:
  1. Only projects with positive net present value should be carried out, and
  2. Of two mutually exclusive projects, the preferred project is the one with the higher net present value.

Private Sector Project Evaluation

Present Value Criterion

$$PV = B_0 - C_0 + \frac{B_1 - C_1}{1+r} + \frac{B_2 - C_2}{(1+r)^2} + \ldots + \frac{B_T - C_T}{(1+r)^T}$$

Annual Net Return			PV of R&D vs. Advertising		
Year	R&D	Advertising	r =	R&D	Advertising
0	-$1,000	-$1,000	0	$150	$200
1	600	0	0.01	128	165
2	0	0	0.05	46	37
3	550	1,200	0.07	10	-21

Note choice of *r* is critical:

- Low *r* benefits Advertising; High *r* benefits R&D.

Internal Rate of Return

- The discount rate (row) that would make a project's net present value zero.

Private Sector Project Evaluation
Internal Rate of Return

IRR: Discount rate that would make a project's NPV zero

$$PV = B_0 - C_0 + \frac{B_1 - C_1}{1+\rho} + \frac{B_2 + C_2}{(1+\rho)^2} + \ldots + \frac{B_T - C_T}{(1+\rho)^T} = 0$$

Project	Year 0	Year 1	ρ	Profit	PV
X	-$100	$110	10%	$4	3.77
Y	-$1,000	$1,080	8%	$20	18.87

This criterion is flawed when comparing projects of much differing sizes. Although X has the higher IRR, Y yields the higher profit. **Note** that the PV criteria, using r=6%, would prefer Y.

Benefit-Cost Ratio

- The ratio of the present value of a stream of benefits to the present value of a stream of costs for a project.

Private Sector Project Evaluation
Benefit-Cost Ratio

$$B = B_0 + \frac{B_1}{1+r} + \frac{B_2}{(1+r)^2} + \ldots + \frac{B_T}{(1+r)^T}$$

$$C = C_0 + \frac{C_1}{1+r} + \frac{C_2}{(1+r)^2} + \ldots + \frac{C_T}{(1+r)^T}$$

Benefit-cost ratio = B/C

Problems with the Benefit-Cost Ratio

"Costs or Negative Benefits?"

Project	B	C	B/C
I	$250	$100	2.5
II	$200	$100	2.0
Suppose that $40 of costs need to be added to project I			
I: Subtract $40 from B?	$210	$100	2.1
OR			
I: Add $40 to C?	$250	$140	1.79

Benefit-Cost criterion can lead to incorrect inferences

Private Sector Project Evaluation

The Present-Value Criterion is the most reliable evaluation guide

- Both IRR and Benefit-Cost Ratio Criteria can lead to incorrect inferences

What is the Appropriate Discount Rate for Government Projects

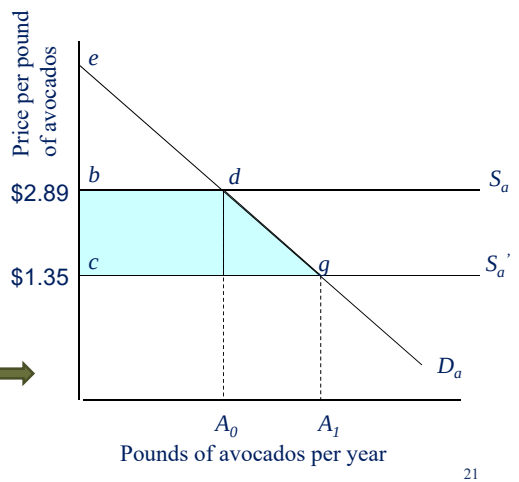
- Based on Returns in Private Sector: the market rate
  - Unfortunately in practice it is hard to determine the actual proportions of sacrificed consumption and investment for a given government project. Even with the information on the impact of each tax on consumption and investment, it is difficult in practice to determine which tax is used to finance which projects.
- Social Discount Rate: the rate at which society is willing to trade off present consumption for future consumption
  - Arguments for SDR:
    - Paternalism- assuming government has better foresight.
    - Market Inefficiency- By applying a discount rate lower than the market's, the government can correct this efficiency. (eg., R&D with positive externalities)
  - Example: Discounting and the Economics of Climate Change
    - Proponents of social discount rates emphasize that discount rates based on the private sector are too high to mirror properly the interests of future generations.

Government Discounting in Practice

- U.S. Office of Management and Budget (OMB) requires federal agencies to use a variety of discount rates, depending on the agency and the type of project
  - One using real discount rate of 7%
  - One using real discount rate of 3%
- Evidence shows that government's incorrect use of discounting has favored policies that increase revenue in the short run, but reduce it in the long run
- Thailand's cases will be presented by a representative from Public Debt Management Office (PDMO) on 31st Oct.

Valuing Public Benefits and Costs

- Use Market Prices? (should reflect Marginal Social Costs and Marginal Social Values)
- Use Adjusted Market Prices in imperfect markets?
  - = Shadow price
  - = underlying social MC of a good
    - Monopoly
    - Taxes
    - Unemployment
- Use Consumer Surplus? ➡



Adjusted Market Prices

- Shadow price- The underlying social marginal cost of a good.
- Consumer surplus- The amount by which consumer's willingness to pay for a commodity exceeds the sum they actually have to pay.

Valuing Public Benefits and Costs

Inferences from Economic Behavior

- How to place a value on the time saved by a proposed project like a new highway?
  - Earnings?
  - Other methods
- How to place a value on a life saved by a proposed project such as a 4-lane divided highway?
  - Lost earnings?
  - Probability of death (eg., fuel efficiency standards)

Valuing Public Benefits and Costs

- Value of life
- The mindset that "life is priceless" presents obvious difficulties for cost-benefit analysis.
- If the benefits of a saved life are infinite, any project that leads to even a single life saved has an infinitely high present value.

Example:

Even if CBA is not explicit, any decision, public or private, reveals a cost-benefit calculus consistent with the observed choice.

Using Mandated Speed Limits to Measure the Value of a Statistical Life

Orley Ashenfelter, Michael Greenstone

NBER Working Paper No. 9094
Issued in August 2002
NBER Program(s): HC LS PE

In 1987 the federal government permitted states to raise the speed limit on their rural interstate roads, but not on their urban interstate roads, from 55 mph to 65 mph for the first time in over a decade. Since the states that adopted the higher speed limit must have valued the travel hours they saved more than the fatalities incurred, this experiment provides a way to estimate an upper bound on the public's willingness to trade off wealth for a change in the probability of death. We find that the 65 mph limit increased speeds by approximately 3.5% (i.e., 2 mph), and increased fatality rates by roughly 35%. In the 21 states that raised the speed limit and for whom we have complete data, the estimates suggest that about 125,000 hours were saved per lost life. Valuing the time saved at the average hourly wage implies that adopting states were willing to accept risks that resulted in a savings of $1.54 million (1997$) per fatality with a sampling error that might be around one-third this value. Since this estimate is an upper bound of the value of a statistical life (VSL), we set out a simple structural model that is identified by variability across the states in the probability of the adoption of increased speed limits to recover the VSL. The impirical implementation of this model produces estimates of the VSL that are generally smaller that $1.54 million, but these estimates are very imprecise.

Raising the maximum speed limit from 55 to 65 increased travel speed by about 2 mph (people often exceed posted speed) saving 45 million hours travel time per year, and inducing about 360 deaths per year (125,000 hours of life).

Our collective decision to drive faster infers that 45 million hours of travel time is worth more that 360 deaths.

Our decisions lead to changes in benefits and costs regardless of whether we make them explicit.

Valuing Public Benefits and Costs
Intangibles

- Intangibles can subvert cost-benefit exercises
- C/B tools can reveal limits on valuing intangibles
- Cost-effectiveness analysis might be best in the presence of intangible benefits
  - Comparing the costs of various alternatives that attain similar benefits to determine which one is the cheapest

Games Cost-Benefit Analysts Play
Common Errors

- The Chain-Reaction Game
  - Including secondary profits (but not costs)
- The Labor Game
  - Including project workers' wages as a benefit (rather than what it is, which is a cost)
- The Double-Counting Game
  - Including benefits from all possible projects, when only one project can be undertaken

Distributional Considerations

Should who gains and who loses be taken into account? Should benefits and costs be weighted?

- NO: Hicks-Kaldor Criterion – a project should be undertaken if it has positive net present value, regardless of distributional consequences
- NO: Let the government costlessly correct any undesirable distributional aspects
- NO: Relies too much on value judgments and politics

Uncertainty

Project	Benefit	Probability	CE*
X	$1,000	1.00	$1,000
Y	0	0.50	$1,000
	$2,000	0.50	

***Certainty Equivalents (Expected Value)**

Certainty Equivalent

- The value of an uncertain project measured in terms of how much *certain* income an individual would be willing to give up for the set of *uncertain* outcomes generated by the project.

An Application:
Are Reductions in Class Size Worth It?

- Discount rate
  - Peltzman (1997) chooses 3, 7 percent.
- Costs
  - Assumes that 10% reduction in class size would require 10% more of all inputs used in public school education.
- Benefits
  - Card and Krueger (1996) estimate that the range of returns to an increase in class size is 0.4 to 1.1 percent. Peltzman takes the midpoint of this range, 0.75 percent.
- The Bottom Line and Evaluation
  - Analysis is often interdisciplinary because economists alone do not have expertise to evaluate all costs and benefits.
  - Evaluation of costs and benefits, especially those arising in the future, is likely to require ad hoc assumptions.
  - In situations characterized by so much uncertainty, it may overburden the analysis to include distributional considerations.
  - For all its limitations, CBA is a remarkably useful way to summarize information.

Application

Table 8.3 Costs and Benefits of Reducing Class Sizes by 10 Percent

	Present Value	
	$r = 7\%$	$r = 3\%$
(1) Costs ($650 annually for 1994 through 2006)	$5,813	$7,120
(2) Benefits ($225 annually for 2007 through 2056)	$1,379	$4,060
(3) Benefits minus costs	−$4,434	−$3,060

Source: Computations based on Peltzman [1997].

These estimates suggest that the costs of reducing class size by 10 percent outweigh the benefits, at either a 3 or 7 percent discount rate.

Use (and Nonuse) by Government

- Using Cost-Benefit Analysis
- Not Using Cost-Benefit Analysis
  - Clean Air Act
  - Endangered Species Act
  - Food, Drug, and Cosmetic Act

Example:

Unskilled Migrant Workforce from AEC Countries and Fiscal Implications for Thailand

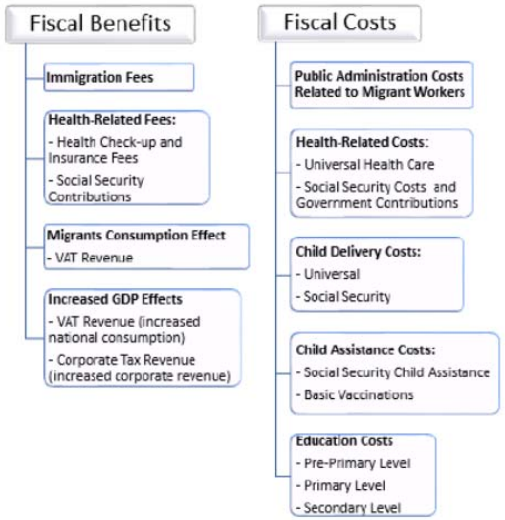
E. Phijaisanit et al. (2017)

Benefit-Cost Analysis

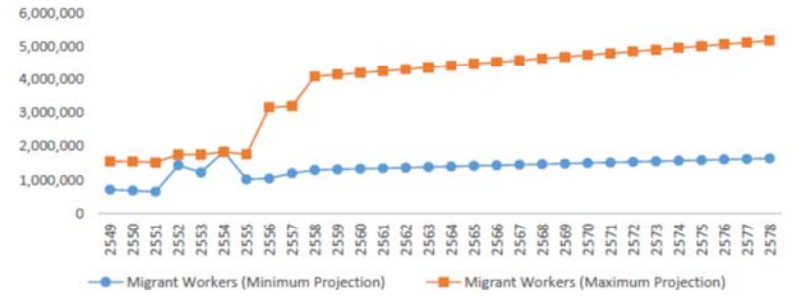
Dustmann and Frattini (2014)

$$GSUR = REV - EXP = \sum_{i=1}^{N_R} rev_i - \sum_{j=1}^{N_E} exp_j$$

Framework for Benefit-Cost Analysis of Fiscal Impacts of Migrant Workers



แผนภาพที่ 8: ขอบเขตการประมาณการจำนวนแรงงานข้ามชาติไร้ฝีมือจาก 3 ประเทศเพื่อนบ้าน



ที่มา: รวบรวมและประมวลข้อมูลจากแหล่งที่มาใน ตารางที่ 2 จำนวนแรงงานข้ามชาติไร้ฝีมือในงานศึกษาผ่านมา)

ตารางที่ 28 สัดส่วนผลประโยชน์ต่อต้นทุนทางการคลัง

	2559	2564	2569	2574	2578
BENEFIT TO COST RATIO (Minimum Projection)	2.8340	2.8121	2.8312	2.8512	2.8692
BENEFIT TO COST RATIO (Maximum Projection)	1.9218	1.9023	1.9045	1.9083	1.9130

ที่มา: ผู้วิจัย

ตารางที่ 29 ผลประโยชน์สุทธิทางการคลังต่อผลิตภัณฑ์มวลรวมภายในประเทศ

	2559	2564	2569	2574	2578
Benefit - Cost (% GDP, Minimum Projection)	0.1006%	0.0861%	0.0736%	0.0628%	0.0628%
Benefit - Cost (% GDP, Maximum Projection)	0.1012%	0.0867%	0.0741%	0.0632%	0.0632%

ที่มา: ผู้วิจัย

ตารางที่ 30 สัดส่วนองค์ประกอบของผลประโยชน์ทางการคลัง กรณี Minimum Projection

Fiscal Benefits (Minimum Projection)	2559	2564	2569	2574	2578
Revenue from Immigration Fees	14.31%	13.00%	11.59%	10.31%	9.36%
Revenue from Health Check-Up & Insurance Fees	60.00%	60.13%	60.67%	61.04%	61.20%
Social Security Contributions	5.89%	6.05%	6.10%	6.14%	6.16%
VAT Revenue from Migrant Consumption	16.63%	17.08%	17.23%	17.34%	17.39%
Tax Revenue from Increased GDP Effects	3.17%	3.75%	4.40%	5.17%	5.89%
Total Fiscal Benefit	100.00%	100.00%	100.00%	100.00%	100.00%

ที่มา: ผู้วิจัย

ตารางที่ 31 สัดส่วนองค์ประกอบของผลประโยชน์ทางการคลัง กรณี Maximum Projection

Fiscal Benefits (Maximum Projection)	2559	2564	2569	2574	2578
Revenue from Immigration Fees	10.54%	9.50%	8.45%	7.51%	6.81%
Revenue from Health Check-Up & Insurance Fees	44.19%	43.97%	44.26%	44.45%	44.54%
Social Security Contributions	4.34%	4.42%	4.45%	4.47%	4.48%
VAT Revenue from Migrant Consumption	38.60%	39.37%	39.63%	39.80%	39.88%
Tax Revenue from Increased GDP Effects	2.34%	2.74%	3.21%	3.77%	4.29%
Total Fiscal Benefit	100.00%	100.00%	100.00%	100.00%	100.00%

ที่มา: ผู้วิจัย

ตารางที่ 32 สัดส่วนองค์ประกอบของต้นทุนทางการคลัง กรณี Minimum Projection

Fiscal Costs (Minimum Projection)	2559	2564	2569	2574	2578
Administration and Related Costs	11.18%	9.47%	8.02%	6.80%	5.97%
Social Security Healthcare Costs	18.38%	18.73%	19.03%	19.28%	19.45%
Universal Health Care Costs	30.11%	30.69%	31.18%	31.59%	31.88%
Child Delivery Costs	4.90%	4.99%	5.07%	5.14%	5.18%
Child Assistance and Vaccination Costs	3.16%	3.22%	3.27%	3.32%	3.35%
Education Costs	32.28%	32.90%	33.42%	33.87%	34.17%
Total Fiscal Cost	100.00%	100.00%	100.00%	100.00%	100.00%

ที่มา: ผู้วิจัย

ตารางที่ 33 สัดส่วนองค์ประกอบของต้นทุนทางการคลัง กรณี Maximum Projection

Fiscal Costs (Maximum Projection)	2559	2564	2569	2574	2578
Administration and Related Costs	5.58%	4.68%	3.94%	3.32%	2.90%
Social Security Healthcare Costs	9.18%	9.27%	9.34%	9.40%	9.44%
Universal Health Care Costs	62.10%	62.70%	63.19%	63.59%	63.87%
Child Delivery Costs	5.44%	5.49%	5.53%	5.57%	5.59%
Child Assistance and Vaccination Costs	1.58%	1.59%	1.61%	1.62%	1.62%
Education Costs	16.12%	16.27%	16.40%	16.51%	16.58%
Total Fiscal Cost	100.00%	100.00%	100.00%	100.00%	100.00%

ที่มา: ผู้วิจัย

Topic 8 Summary

- Cost-Benefit analysis is used to evaluate potential public sector projects
- Present value of future expected costs and benefits must be calculated in order to allow correct comparisons
- Although the IRR and B-C Ratio are used to evaluate projects, the NPV criterion has fewer biases and problems
- Choice of the discount rate is critical
- The costs and benefits of public projects can be measured using market prices in the absence of market failures. Otherwise, shadow prices or consumer surplus can be used

CONT ⟶

Topic 8 Summary (cont)

- Quantifying the value of time and life, is necessary in measuring benefits, but using earnings as a proxy has limitations
- Whether the distribution of future costs and benefits on various groups of people should be included in CBA is under debate
- Uncertainty of future costs and benefits can be included through the use of certainty equivalents

Discussion questions

- Selected discussion in class