LECTURE V:

Cost-Benefit Analysis

The Fundamental Questions

- How do we measure the costs and benefits associated with a public project?
- What are the methods used to evaluate costs and benefits for things that there are no prices?
- How do we compare complex costs and benefits in assessing the optimality of public projects?

Answers

- In this lecture we provide answers to these questions using the theoretical tools we reviewed in studying the choices of consumers and firms and the workings of markets and their properties (efficiency and equity), as well the theoretical analysis of externalities and public goods, presented in the previous two chapters.

Cost-Benefit Analysis

- The comparison of costs and benefits of public projects to decide if they should be undertaken.

The best way to understand cost-benefit analysis is through a specific example.

The Highway Project

TABLE 8-1

Cost-Benefit Analysis of Highway Construction Project

		Quantity	Price/Value	Total
Costs	Asphalt	1 million bags		
	Labor	1 million hours		
	Maintenance	$10 million/year		
			First-year cost:	
			Total cost over time:	
Benefits	Driving time saved	500,000 hours/year		
	Lives saved	5 lives/year		
			First-year benefit:	
			Total benefit over time:	
			Benefit over time minus cost over time:	

The renovation of the turnpike in your state has three costs: asphalt, labor, and future maintenance. There are two associated benefits: reduced travel time and reduced fatalities. The goal of cost-benefit analysis is to quantify these costs and benefits.

Measuring the Costs of Public Projects

- It would seem appropriate to use **cash-flow accounting**, that calculates solely by adding up what the government pays for inputs to a project and calculates benefits solely by adding up income or government revenues generated by a project.
- But, this method does not measure the (economic) costs and benefits used in public economics and, in particular, these costs and benefits that are needed to compute marginal social costs and marginal social benefits.

Opportunity Cost

- The opportunity cost of any resource is the value of that resource in its next best use.
- Example 1: The next best use for a a bag of asthalt, besides using it on this project, is to sell the bag to someone else. If the market for asphalt is competitive, the value of this alternative use is the market price of the bag.
- If a good is sold in a competitive market, then the opportunity cost for this good is its market price.

Opportunity Cost and Rent Transfers

- Example 2: Suppose that the wage rate for construction workers is €20 per hour, but the best alternative for the time of a construction worker is watching TV and construction workers value this activity at €10 per hour. The opportunity cost of construction workers employed somewhere else is €20 per hour and the opportunity cost of unemployed construction workers is €10 per hour.
- **Rent Transfers**: Payments to resource deliverers that exceed those necessary to employ the resource
- Example 2 cont.: Paying €20 per hour to unemployed construction workers results in a transfer of rents at the rate of €10 per hour.

Opportunity Cost and Rent Transfers

- Example 3: Suppose that the asphalt is sold to the government not by a perfectly competitive firm, but by a monopoly. The opportunity cost of the asphalt is the marginal cost of its production and the difference between the price paid for the bag of asphalt and the marginal cost of its production is a rent transfer from the government to the monopolist.

Future Costs and Benefits and **Present Discounted Value (PDV)**

A euro next year is worth 1+r times less than a euro now, because the euro now, if invested, could earn r% interest.

$$NPV_0 = (Benefit)_0 - (Cost)_0 + \frac{(Benefit)_1 - (Cost)_1}{1 + r_1} + \ldots$$

$$+ \frac{(\mathrm{Benefit})_t - (Cost)_t}{(1 + r_1)\ldots(1 + r_t)} + \ldots + \frac{(\mathrm{Benefit})_T - (Cost)_T}{(1 + r_1)\ldots(1 + r_t)\ldots(1 + r_T)}$$

$$NPV_0 = (Benefit)_0 - (Cost)_0 + \frac{(Benefit)_1 - (Cost)_1}{1+r_1} + \ldots$$

$$+ \frac{(\text{Benefit})_t - (Cost)_t}{(1+r_1)\ldots(1+r_t)} + \ldots + \frac{(\text{Benefit})_T - (Cost)_T}{(1+r_1)\ldots(1+r_t)\ldots(1+r_T)}$$

If $r_t = r$ for all t,

$$NPV_0 = (Benefit)_0 - (Cost_0) + \sum_{t=1}^{T} \frac{(Benefit)_t - (Cost)_t}{(1+r)^t}$$

If $(Benefit)_t - (Cost)_t = (Benefit) - (Cost)$ for all t,

$$NPV_0 = (Benefit)_0 - (Cost)_0 + [(Benefit) - (Cost)] \frac{\left(\frac{1}{1+r}\right)^{T+1} - \left(\frac{1}{1+r}\right)}{\left(\frac{1}{1+r}\right) - 1}$$

And, if $T \to +\infty$

$$PPV_0 = (Benefit)_0 - (Cost)_0 + \frac{(Benefit) - (Cost)}{r} .$$

Digression on NPV and Internal Rate of Return (IRR)

$$IRR, \ i \ni$$

$$0 = (Benefit)_0 - (Cost)_0 + \frac{(Benefit)_1 - (Cost)_1}{1+i} + \ldots$$

$$\ldots + \frac{(\text{Benefit})_t - (Cost)_t}{(1+i)^t} + \ldots + \frac{(\text{Benefit})_T - (Cost)_T}{(1+i)^T}$$

Digression on NPV and Internal Rate of Return (IRR)

- IRR is useful when you have to evaluate several projects, for unlike NPV, the scale of the project does not matter.

Social Discount Rate

- The appropriate value of r to use in computing PDVs or comparing IRRs to a threshold r.
- The social discount rate may be different than the discount rate of private investors.
- Example 1: The proper discount rate for a firm that was making an investment decision represents the opportunity cost of what else the firm could accomplish with those same funds. If there is an existing investment that yields 10% per year, with certainty, and the firm pays a tax at a 50% rate, then this investment would net the firm a return of 5% per year. But, if the opportunity cost of government is giving the funds to the private sector, the social discount rate is 10%.

Social Discount Rate

- For projects with costs and/or benefits with long time horizons, NPVs are very sensitive to the discount rate.
- Do future generations matter and how much do they matter?

Costs in the Highway Project

Cost-Benefit Analysis of Highway Construction Project

		Quantity	Price/Value	Total
Costs	Asphalt	1 million bags	$100/bag	$100 million
	Labor	1 million hours	½ at $20/hour and ½ at $10/hour	$15 million
	Maintenance	$10 million/year	7% discount rate	$143 million
			First-year cost:	**$115 million**
			Total cost over time:	**$258 million**
Benefits	Driving time saved	500,000 hours/year		
	Lives saved	5 lives/year		
			First-year benefit:	
			Total benefit over time:	
			Benefit over time minus cost over time:	

The cost of the asphalt for this project is dictated by the market price for asphalt, $100 per bag. The cost of labor depends not on the wage, but on the full opportunity cost of the labor, which incorporates the current unemployment of any workers who will be used on the project. The cost of future maintenance is the present discounted value of these projected expenditures.

Measuring the Benefits of Public Projects

- In general, it is more difficult to measure the benefits than the costs of public projects.
- We will use two examples:

(i) the value of time

(ii) the value of life

but the three alternative methods we will use:

(a) market-based measures

(b) survey – based measures

(c) revealed preferences

Value of Time

(a) Market- based measures: If labor markets are competitive, we could use the the drivers' wages to value their time savings.

Problems: indivisibilities in the supply of labor

non monetary benefits associated with jobs

Value of Time

(b) Survey-based measures: We could ask all those that they are potentially affected by the project: "How much would you pay to save five minutes on your drive?"

Problems with contingent valuation: (i) isolation of issue matters

(ii) other issues matter

(iii) "embedding effect"

Value of Time

- (c) The principle of revealed preferences ("People may lay, but their actions don't.): We could use the difference in sales prices between two homes, one which is five minutes closer to the central city where most commuters work, to assign a value to saving five minutes of commuting

Problems: selectivity bias vs hedonic prices

Value of Time

- Price of any good reveals values the entire set of attributes of that good, but revealed preferences analysis looks to one particular attribute.
- Controlled experiments not possible in most cases.

Value of Life

Some argue that life is priceless. Thus, any amount of money should be paid to save a life. Based on this argument, the valuation of life is a reprehensible activity.

In public economics we take the view that resources are scarce and government programs compete for the very same scarce resources and any government program may save lives (e.g.,"education reduces crime"). Thus, we can value programs only if we put a value in life.

Value of Life

(a) Market-based measures: We could compute the present value of the stream of expected lifetime earnings, including the value of leisure.

Problems: discounting, uncertainty, utility of nonmonetary things

(b) Contingent valuation: Ask individuals about the value they assign to of things that reduce the probability of dying (i.e., value of thing = decrease in the probability of dying X value of life)

Problems: As in the case with the value of time

Surveys give unrealistically wide range of values

Value of Life

(c) Revealed Preferences: Use **compensating differentials.** That is additional (reduced) wage payments to workers to compensate them for the negative (positive) amenities of a job, such as increased risk of mortality (a nicer office).

This is the preferred method of economists. Kip Viscusi of Harvard ~ €8.73 million

Problems: strong informational assumptions

perception of risk are different from objective or rational probabilities

behavioral characteristics (overstate small risks + understate big risks)

separation of attributes

heteregoneus individuals

(d) Government-Revealed Preferences: What was actually spent to save lifes

Problems: wide range of values

Benefits of the Highway Project

Cost-Benefit Analysis of Highway Construction Project

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	Maintenance	$10 million/year	7% discount rate	$143 million
			First-year cost:	**$115 million**
			Total cost over time (7% discount rate):	**$258 million**
Benefits	Driving time saved	500,000 hours/year	$19/hour	$9.5 million
	Lives saved	5 lives/year	$7 million/life	$35 million
			First-year benefit:	**$44.5 million**
			Total benefit over time (7% discount rate):	**$635.7 million**
			Benefit over time minus cost over time:	**$377.7 million**

The time savings from this project is most appropriately valued by the revealed preference valuation of time, which is $19/hour. The life savings is most appropriately valued by the revealed preference value of life, which averages $7 million. The present discounted value of costs for this renovation project is $258 million, while the *PDV* of benefits for this project is $635.7 million. Because benefits exceed costs by $363.4 million, the project should clearly be undertaken.

Other issues

- Counting secondary benefits (total surplus matters)
- Counting labor as benefit (wages are part of costs)
- Double counting benefits (rise in house values vs reduction in travel time)
- Distributional concerns (compensating "losers" might not be possible)
- Uncertainty (risk aversion)

Exercises

1. A new public works project requires 200,000 hours of labor to complete.

a. Suppose that the labor market is perfectly competitive and the market wage is $15. What is the opportunity cost of the labor employed for the project?

b. Suppose that there is currently unemployment among workers, and that there are some workers who would willingly work for $10 per hour. What is the opportunity cost of the labor employed? Does this vary depending on the fraction of would-be unemployed workers hired for the project?

c. If your answers to (a) and (b) differ, explain why.

3. The city of Metropolita added a new subway station in a neighborhood between two existing stations. After the station was built, the average house price increased by $10,000 and the average commute time fell by 15 minutes per day. Suppose that there is one commuter per household, that the average commuter works 5 days per week, 50 weeks per year, and that the benefits of reduced commuting time apply to current and future residents forever. Assume an interest rate of 5%. Produce an estimate of the average value of time for commuters based on this information.

Plan B calls for imposing a toll of $6 for crossing the bridge, with the remainder of the cost to be paid out of tax revenues. City planners estimate a local demand curve for hourly use of the bridge to be $Q = 1{,}800 - 100P$. The bridge will be able to accommodate 2,000 cars per hour without congestion. Which of the plans is more efficient, and why? How would your answer change if congestion were predicted on the bridge?