BENEFIT-COST ANALYSIS

LESSON OBJECTIVES

01

Explain and analyze social choice theory

02

Explain the process of benefit-cost analysis

03

Explain arguments for and against benefit-cost analysis

POLICY PROPOSAL: BUILDING A NEW HIGHWAY

Should it be built?

Should Marta be extended instead?

What type of road surface should be used?

AIR QUALITY REGULATION

Should we try to improve air quality?

How should we regulate it?

- Leave it up to firms?
- Tax?
- Technology standard?

BENEFIT COST ANALYSIS (BCA)

Process of evaluating policies whereby you:

- Catalogue the impacts of a project or activity as benefits (pros) and costs (cons);

- Value the benefits/costs in terms of dollars (this assigns weights that are comparable);

- Determine the net benefit (= total benefits – total costs) relative to the status quo

BCA for policy purposes takes a societal perspective (i.e., social costs/social benefits)

WHO BENEFITS?
WHO PAYS THE COST?

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WHO PAYS THE COST?

NPV tells us about efficiency

Are all efficient policies fair? No!

Example: Increase gas tax to reduce emissions
- Who benefits?
- Who pays the cost?
- Policy may be efficient, but regressive

Not all environmental policies are regressive

Efficiency and distribution should be seen as separate

SO WHY ALL THE TALK ABOUT EFFICIENCY?

01

SOCIAL CHOICE

PARETO EFFICIENCY

Pareto (1920) proposes what's termed **Pareto Efficiency**

> *A policy is **Pareto efficient** if—and only if—no member of society could be made better off by an alternative policy without making at least one person worse off.*

Foundation of welfare economics

Is this a good criterion for policy?
Is this a *reasonable* criterion for policy?

Example: Technological innovation that made everyone better off except one person

PARETO EFFICIENCY

Pareto criterion formally described by

$$\max_{\{q\}} \sum_i [B_i(q) - C_i(q)]$$
$$s.t. \, B_i(q) - C_i(q) > 0 \, \forall i$$

Pareto efficiency is too strict, so what can we do?
Kaldor and Hicks (1939) propose **potential Pareto improvement**

A policy is a potential Pareto improvement if it would make at least one person better off without making anyone worse off, provided that suitable transfers were made from the winners to the losers.

Idea: Policy is an improvement if the gains of winners>loss of losers

Kaldor-Hicks is a necessary condition for the Pareto condition

Can use Kaldor-Hicks as a *weaker* condition to filter really bad policy

Consider two policy alternatives:
<u>Policy 1:</u> Benefits = $10M, Costs = $5M
<u>Policy 2:</u> Benefits = $10M, Costs = $3M

Alone, each policy satisfies the condition that B>C
Further, change from Policy 1 to Policy 2 -> $\Delta B > \Delta C$
- Thus, the change also is a Kaldor-Hicks improvement

Kaldor-Hicks criterion serves as the foundation for BCA
- Caveat is that it must be done correctly

Kaldor-Hicks criterion formally described by

$$\max_{\{q\}} \sum_i [B_i(q) - C_i(q)]$$

Notice, the constraint is dropped from Pareto criterion

UNDER KALDOR-HICKS, THE WINNERS *COULD* COMPENSATE THE LOSERS

PROBLEM

<u>Idea:</u>
- Sometimes you are a winner, sometimes a loser
- In the long-run, it will balance out and **everyone** is better off

Does this actually happen?

ATTENDANCE ACTIVITY

Consider a policy to improve air quality in 2 towns (A and B) by regulating air pollution of manufacturing firms.

You perform an analysis in which you quantify the benefits and costs associated with the program.

You find that:
- In town A, the benefits of the regulation are $40 million and the policy would have a cost of $50 million.
- In town B, the benefits of the regulation are $50 million and the costs are $30 million.

Is this regulation Pareto improvement (satisfy the Pareto Efficiency criterion)?
Is this regulation a potential Pareto improvement (satisfy the Kaldor-Hicks criterion)?
If the policy is not a Pareto improvement, what could happen to make it a Pareto improvement?

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Is this regulation Pareto improvement (satisfy the Pareto criterion)?

No! For town A, B-C = $40-$50 = -$10 million.

Is this regulation a potential Pareto improvement (satisfy the Kaldor-Hicks criterion)?

Yes, B+C = ($40-$50)+($50-$30) = $10 million

If the policy is not a Pareto improvement, what could happen to make it a Pareto improvement?

Town B could compensate town A $20million>x>$10 million

02

BENEFIT-COST ANALYSIS

BENEFIT COST ANALYSIS (BCA)

Use of BCA in the US varies across policies and regulating entities
- Safe Drinking Water Act requires BCA
- Clean Air Act forbids the consideration of costs

In the US, **Regulatory Impact Analysis** (RIA) has been required by every president since Nixon for all environmental, health, and safety regulations expected to have **significant costs**
- Significant cost set at $100 million/year since Reagan

9 STEPS OF RIA

1. Define the need for the regulatory action
2. Define the baseline
3. Set the time horizon of the analysis
4. Identify a range of regulatory alternatives
5. Identify the consequences of regulatory alternatives
6. Quantify and monetize the benefits and costs
7. Discount future benefits and costs
8. Evaluate non-quantified/non-monetized benefits and costs
9. Characterize uncertainty in benefits, costs, and net benefits

EXAMPLE I: BUILDING A NEW HIGHWAY

STEP 1: DESCRIBE THE NEED FOR THE REGULATORY ACTION

Why is the city building a new highway right now?

- Required by law?

- Court ruling?

- Administrator initiative?

Highway Example
State government initiative

STEP 2: DEFINE A BASELINE

BCA measures costs and benefits *relative* to some baseline
- Usually the status quo

Difficulty is the status quo is hard to know too
- Unknown factors: economic growth, technology, market changes

Policies often overlap
- Expansion of subway may impact traffic

Highway example
Status quo

TABLE 5. Generation mix with the base case and the MATS, 2015 (thousands of GWh)

	2009	2015		
	Historical	Base case	Policy case	% Change from base
Coal	1,741	1,982	1,957	−1.3
Oil	36	0.11	0.11	3.6
Natural gas	841	710	731	3.1
Nuclear	799	828	831	0.4
Hydroelectric	267	286	288	0.8
Non-hydro renewables	116	252	250	−0.6
Other	10	45	45	0.0
Total	3,810	4,103	4,104	0.0

Source: RIA, Table 3-6.

Net generation, United States, all sectors, annual

thousand megawatthours
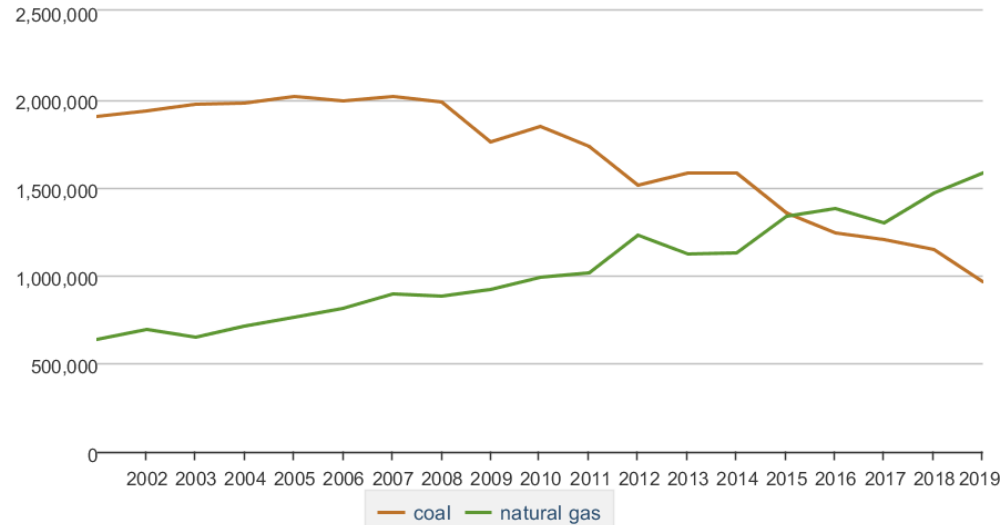
Data source: U.S. Energy Information Administration

STEP 3: SET TIME HORIZON OF ANALYSIS

How long will the regulation have economic effects?
- Should be long enough to encompass the important benefits and costs

How long can you reasonably predict the future?
- If no sunset provision, need to choose endpoint based on forecasting ability

Highway example:
Time horizon set at expected lifetime of the highway (20 yrs)

STEP 4: IDENTIFY RANGE OF REGULATORY ALTERNATIVES

For policy regulations can consider:
- Standards vs. markets
- Stringency
- Compliance dates

For projects can consider alternatives

Highway example:
Bitumen surface vs. concrete
Toll vs. no-toll

STEP 5: IDENTIFY CONSEQUENCES OF REGULATORY ALTERNATIVES

What are the benefits and costs?

Considerations:
When will they occur?
What are the geographic limits?
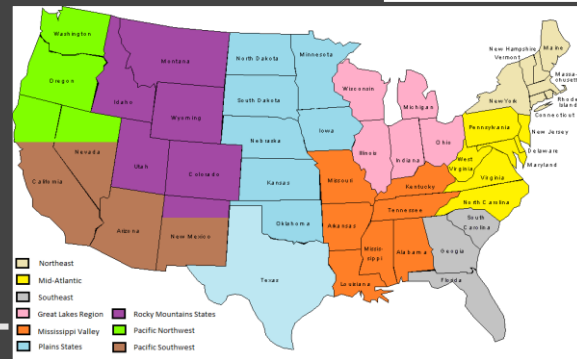Primary/secondary effects?
Distributional impacts?

STEP 5: IDENTIFY CONSEQUENCES OF REGULATORY ALTERNATIVES

For example, should only the benefits/costs to the state where the highway is built be counted?

Or should a regional perspective be taken?

Or national?

STEP 5: IDENTIFY CONSEQUENCES OF REGULATORY ALTERNATIVES

Impacts include all <u>inputs</u> into the project and all <u>outputs</u> from the project.

Inputs in our example would include:
- Construction & maintenance activities (labor, construction materials, consultants (legal experts, project managers, etc.))
- Toll collection activities (labor, etc.)

STEP 5: IDENTIFY CONSEQUENCES OF REGULATORY ALTERNATIVES

Impacts include all <u>inputs</u> into the project and all <u>outputs</u> from the project.

Outputs in our example would include:
- Time saved for travelers through reduced congestion
    - have to predict number of vehicle trips on new road, change in trips on other roads.
- Revenues collected from tolls
- Changes in pollution (if volume increases in response to reducing cost of commuting)
- Accidents avoided (through reduced congestion).
    - Again, have to predict number of crashes, number of injuries, and number of deaths avoided.

STEP 6: QUANTIFY AND MONETIZE THE BENEFITS AND COSTS

To be comparable, all impacts must be monetized

Costs are often more straightforward
(cost of labor, materials, etc.)

Benefits are sometimes very difficult, especially when it comes to environmental projects.

Highway example:
$ value of time saved
$ value of accidents avoided
($ value of injuries avoided, deaths avoided & auto damages avoided)
Etc.

STEP 7: DISCOUNT FUTURE BENEFITS AND COSTS

For comparison, must compute net present value

$$NPV = \sum_{t=0}^{T} \frac{B_t - C_t}{(1 + r)^t}$$

What r?
- Market rate or Intergenerational social discount rate?
- Office of Management and Budget recommends comparing 3% and 7%

Remember, choice of discount rate can have a large effect on NPV, especially for long time horizons

Highway example:
Calculate at 3% and 7%

STEP 8: EVALUATE NON-QUANTIFIED AND NON-MONETIZED BENEFITS AND COSTS

Sometimes identified impacts cannot be quantified or monetized
- E.g. no models or studies to use
- Data does not exist

Quantify when cannot monetize

Qualitative description when cannot quantify

STEP 9: CHARACTERIZE UNCERTAINTY IN BENEFITS AND COSTS

What are the sources of uncertainty? Impacts? Value?
- E.g. discount rate, economic growth, traffic

If few sources:
- Present sensitivity analysis for different parameter values

If many sources:
- Full probabilistic characterization (Monte Carlo)

Highway example:
Sensitivity analysis for different discount rates across traffic forecasts
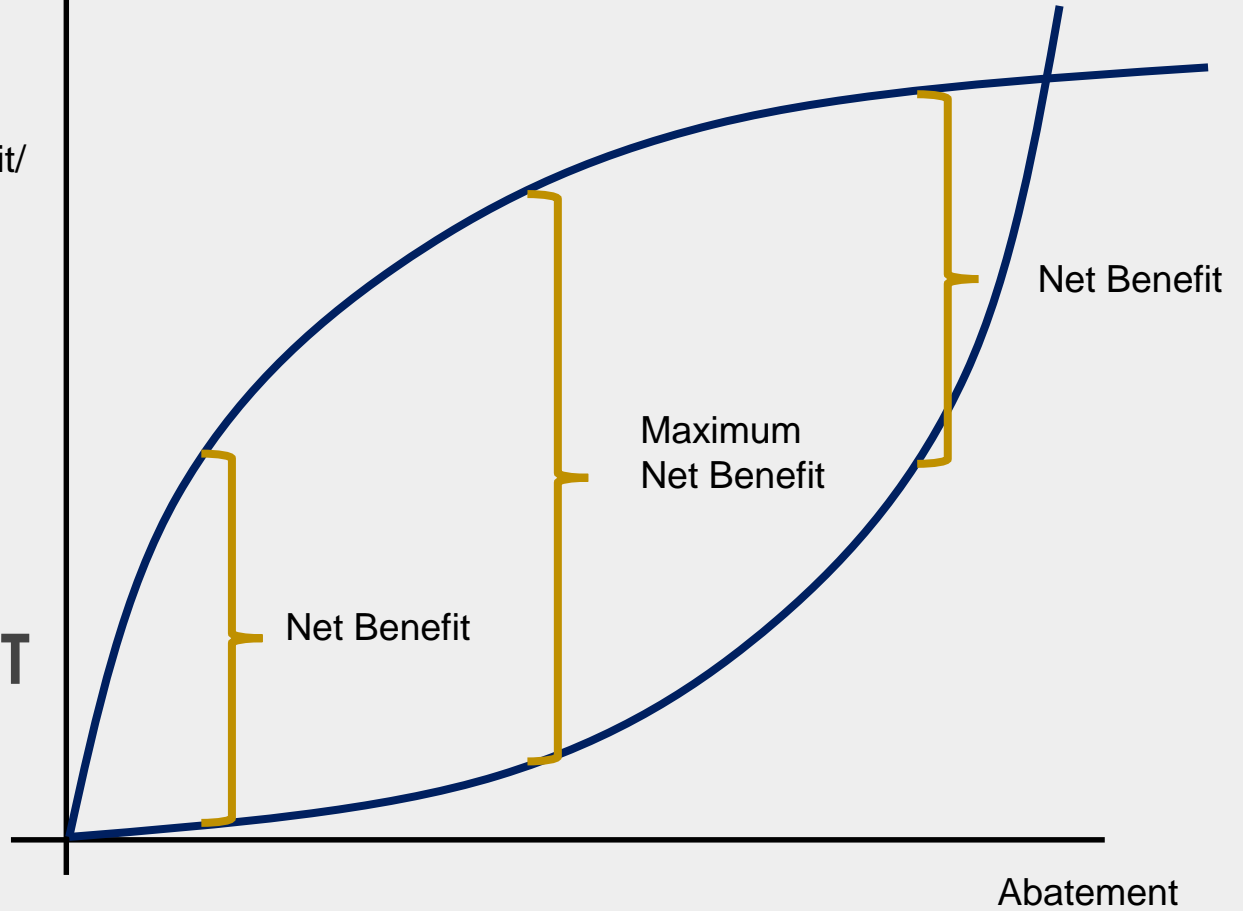
CONGRATS! RIA IS COMPLETE NOW WHAT?

How do we decide to accept or reject the policy or project?

Does this tell us if net benefits are maximized?

EFFICIENT OUTCOMES

Maximizes net present values

If NPV>0 does it maximize NPV?
- Probably not…

What can it tell us?
- Getting closer to efficient outcome (Kaldor-Hicks)

So…
Typically adopt project/policy if NPV>0
If multiple alternatives, choose highest NPV

UNDER KALDOR-HICKS, THE WINNERS *COULD* COMPENSATE THE LOSERS

PROBLEM

Idea:

- Sometimes you are a winner, sometimes a loser

- In the long-run, it will balance out and **everyone** is better off

Does this actually happen?

DOES THIS ACTUALLY WORK OUT?

In 1978 Ward Transformer Co illegally dumped 31K gallons of PCB along 240 of highway in 14 counties of NC

EPA to dispose of 60K tons of contaminated soil in a landfill

NC proposed 2 sites to dispose of the soil:

- Warren county: 60% black, 25% below the poverty line
  - Shallow water table, not well suited for a landfill

- Chatham county: 27% black, 6% below the poverty line
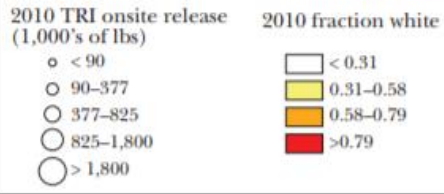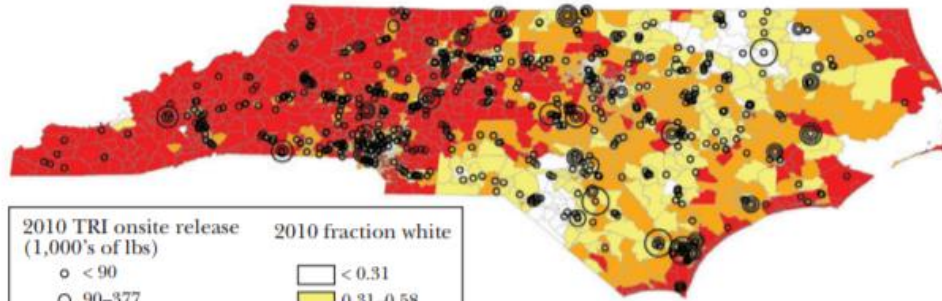 - Suitable site available

Warren selected despite resident complaints of potential for contamination, which was later found in 1993

- Widely credited with initiating the Environmental Justice Movement

MANY STUDIES FIND EVIDENCE THAT ENVIRONMENTAL BURDEN IS NOT EQUITABLE

Figure 1

Emissions from Large Polluters and Fraction Non-Hispanic White for North Carolina, 2010

2010 TRI onsite release (1,000's of lbs)
- ○ < 90
- ○ 90–377
- ○ 377–825
- ○ 825–1,800
- ○ > 1,800

2010 fraction white
- ☐ < 0.31
- ☐ 0.31–0.58
- ☐ 0.58–0.79
- ☐ >0.79

Source: Authors using data from the Toxic Release Inventory and US Census.
Note: Using data from the Toxic Release Inventory (TRI), Figure 1 plots emissions from large polluters in North Carolina in the year 2010 with circles, against a heat map of the percentage of the population that is non-Hispanic white at the census tract level.

Source Banzhaf et al. (2019)

POSSIBLE MECHANISMS

1. Disproportionate siting
2. "coming to the nuisance"
3. Coase bargaining
4. Political discrimination
5. Imperfect information

PROBLEM

Kaldor-Hicks seemed reasonable if identity of winners and losers varied. But what if it doesn't?

New criterion?

MODIFIED SOCIAL OBJECTIVES

For example, we could weight individuals (ω_i) by race or income

$$\max_{\{q\}} \sum_i \omega_i [B_i(q) - C_i(q)]$$

Note, this critique does not invalidate the use of the BCA tool, but rather the implementation or the social objectives imposed

WHAT ELSE COULD WE DO?

Remember way back I said to treat efficiency and equity separately.

There are trade-offs involved. One of these can often be between efficiency and equity of policy.

BCAs are supplemented with a distributional impact analysis.

WHAT ARE OTHER CRITIQUES OF BENEFIT-COST ANALYSIS?

BENEFIT–COST ANALYSIS SHOULD NOT BE THE ONLY CRITERION FOR DECISION MAKING

We have just discussed some deficiencies that can occur with BCA

For that reason, rarely used as the only criterion

However, BCA provides a normative framework and can highlight important tradeoffs involved

DISCOUNTING IS UNFAIR TO FUTURE GENERATIONS

Discounting can lead to clear issues of intergenerational equity
- Ex.: Discounting suggests we should let Florida be destroyed 200yrs from now by asteroid

What's the alternative?
- 0% seems wrong too
- People make these tradeoffs every day

Again, highlights need to consider alternative criterion

PUTTING BENEFITS IN DOLLAR TERMS CHEAPENS THE WORTH OF THE ENVIRONMENT

Monetization provides common unit

What's the alternative
- Other metrics would be seemingly just as difficult

Moral Imperative argument
- Sometimes they conflict

Again, tradeoffs!

BENEFIT-COST ANALYSIS IGNORES THE LOSERS FROM A POLICY

See the above discussion about who wins/loses and social choice.

There exists a tradeoff between equity and efficiency

Need to evaluate both!

BCA IN REVIEW

BCA provides a normative framework to evaluate projects and regulations

When done *correctly*, can move toward efficiency
- Sometimes it is hard to do *correctly*

Important to recognize efficiency vs. equity tradeoff

Important to consider sources of uncertainty

LESSON OBJECTIVES

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Explain and analyze social choice theory

02

Explain the process of benefit-cost analysis

03

Explain arguments for and against benefit-cost analysis