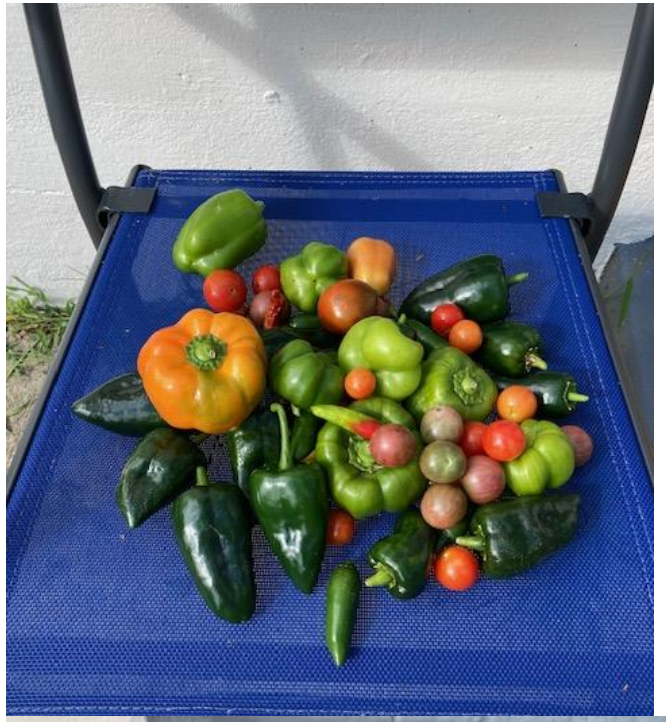
# Lecture 12: Benefit Cost Analysis

Prof. Austin
Environmental Economics
Econ 4075

# Roadmap for Today

Topics

- Foundations
- How to conduct a benefit cost analysis
- Limitations of benefit cost analysis
- Equity weights



This weekend's harvest.

# Part 1: Foundations

# Benefit Cost Analysis Overview

A benefit cost analysis (BCA) quantifies the benefits and costs of a policy proposal and some alternatives. It is one part of a complete economic analysis. A regulatory impact analysis can also include:

- Distributional analysis
- Environmental Justice analysis
- Small business analysis
- Cost effectiveness analysis
- Others

Of course, economics and BCA is just one criteria by which to assess policy.

- Ethics, legality, feasibility, compliance incentives

# Relevance of the Benefit Cost Analysis

Every year, the White House's Office of Management and Budget submits a 100+ page report to congress on the benefits and costs of all regulations.

- BCA is very important in shaping policy.
- Valuable to know how it works.

**Table 1-5: Estimates, by Agency, of the Total Annual Benefits and Costs of Major Rules (For Which Both Benefits and Costs Have Been Estimated): October 1, 2015 - September 30, 2016 (billions of 2001 or 2015 dollars)**

| Agency | Number of Rules | Benefits | | Costs | |
|---|---|---|---|---|---|
| | | 2001$ | 2015$ | 2001$ | 2015$ |
| Department of Agriculture | 1 | $0.0 to $0.1 | $0.0 to $0.2 | <$0.1 | <$0.1 |
| Department of Energy | 4 | $2.9 to $4.7 | $3.8 to $6.2 | $0.2 to $0.8 | $0.3 to $1.1 |
| Department of Health and Human Services | 2 | $0.7 to $7.3 | $0.9 to $9.6 | $0.3 to $0.7 | $0.4 to $0.9 |
| Department of Homeland Security | 1 | $0.1 to $0.4 | $0.2 to $0.5 | $0.1 | $0.2 |
| Department of Transportation | 2 | $2.4 to $4.0 | $3.1 to $5.2 | $1.4 to $1.6 | $1.8 to $2.1 |
| Environmental Protection Agency | 5 | $9.4 to $11.5 | $12.3 to $15.1 | $1.6 to $1.7 | $2.1 to $2.2 |
| Joint Department of Transportation and Environmental Protection Agency | 1 | $6.7 to $9.7 | $8.8 to $12.8 | $0.8 to $1.1 | $1.1 to $1.5 |
| **Total** | **16** | **$14.0 to $28.0** | **$18.4 to $36.7** | **$3.3 to $4.9** | **$4.4 to $6.5** |

Source: See more OMB reports to Congress.

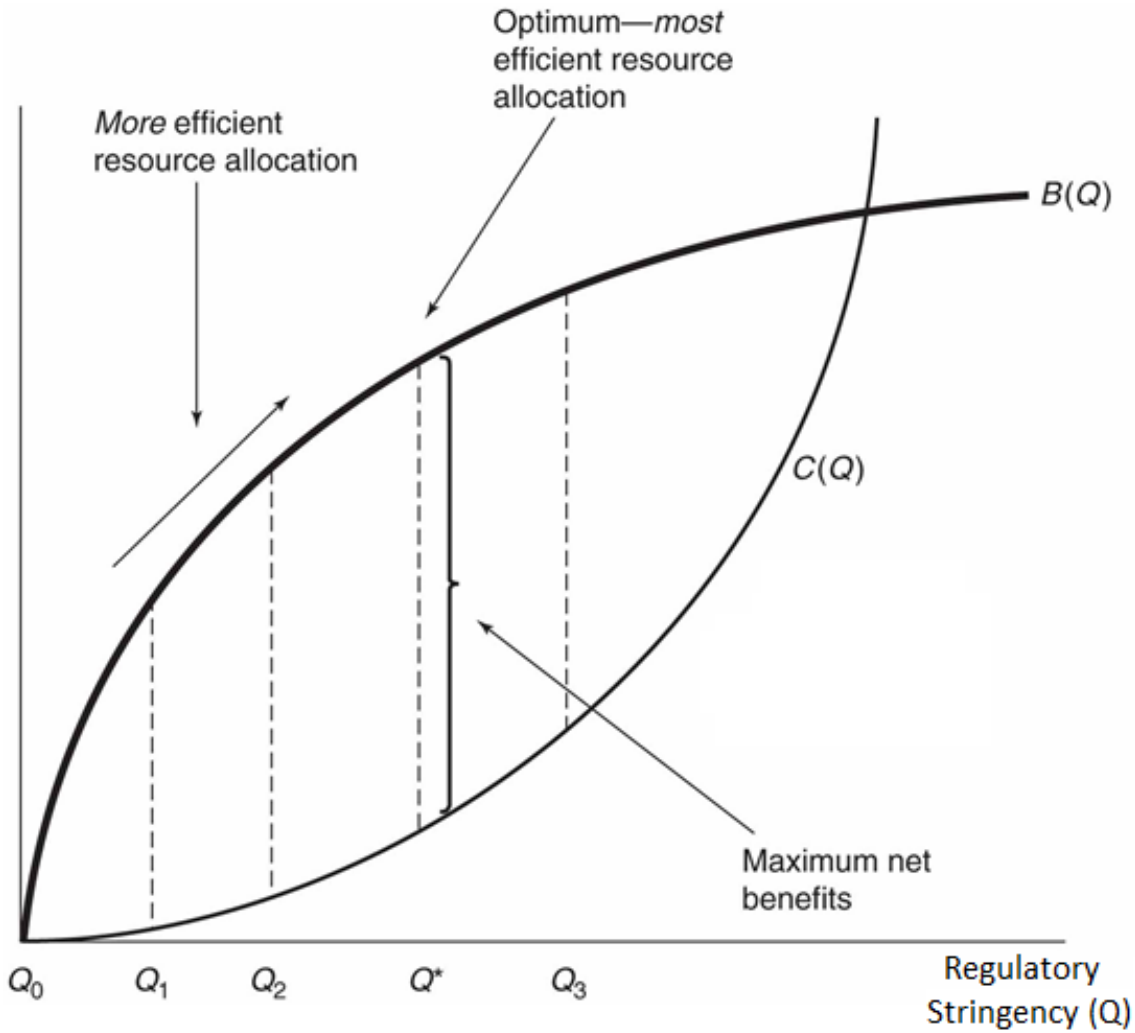
# What does a BCA do?

BCA provides a way to compare different policy choices on the grounds of economic efficiency.

- The most economically efficient allocation maximizes net benefits.

$$Net\ Benefits = Benefits\ - Costs$$

- A policy can increase or decrease net benefits.
  - Increasing net benefits → more efficient
  - Decreasing net benefits → less efficient



# Benefit Categories

**Total Value**: An individual's willingness to pay to preserve or maintain a resource in its current state.

Total Value = use value + non-use value.

- Use Value: Economic value associated with the use of a resource (e.g., through visiting a recreation site).
- Non-Use Value: All remaining components of total value that arise independent of use.
  - Non-use values are particularly important in cases where the resource in question is unique and when the loss is irreversible.

# Benefit Categories

For most BCA, valuation categories are more readily observable and market-based use values.

Valuation of environmental goods is primarily less observable non-use values, making environmental BCA more challenging and also controversial.

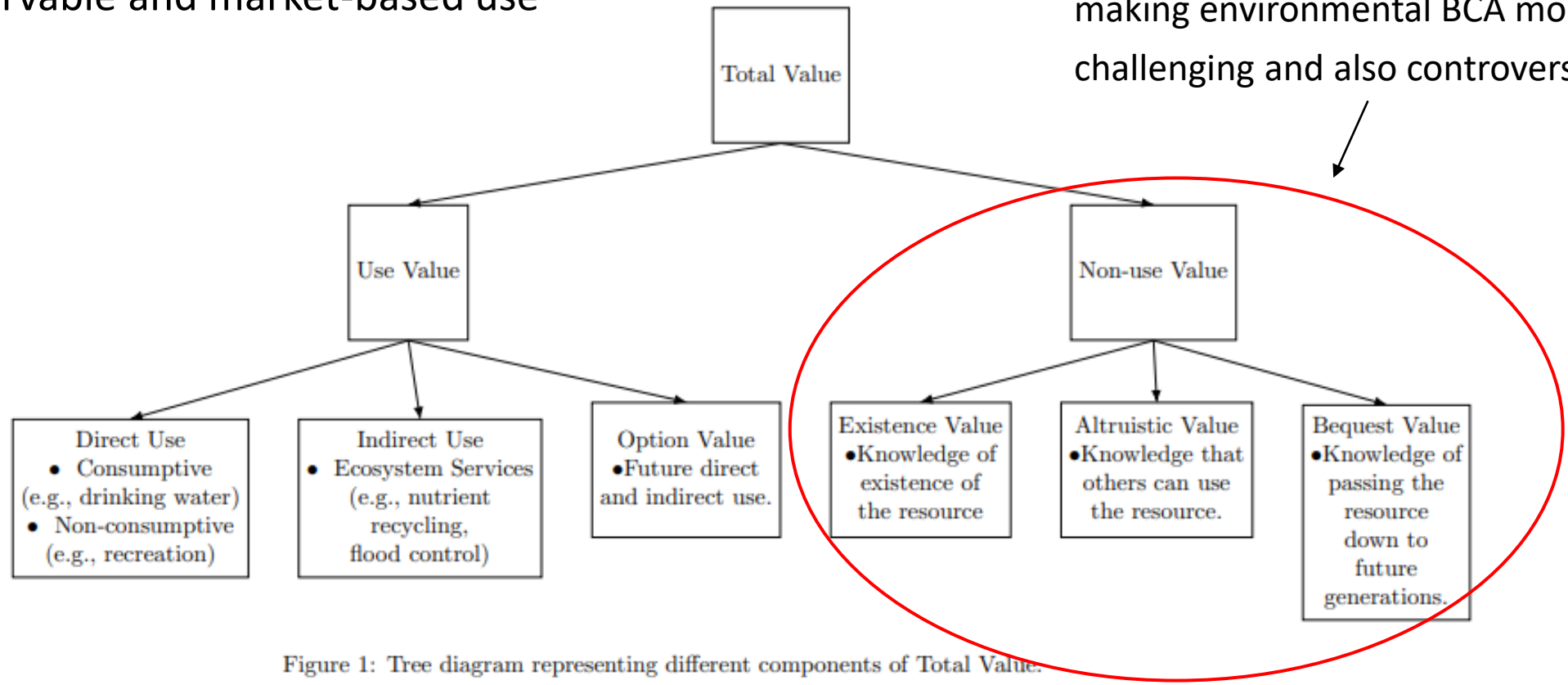



Figure 1: Tree diagram representing different components of Total Value.

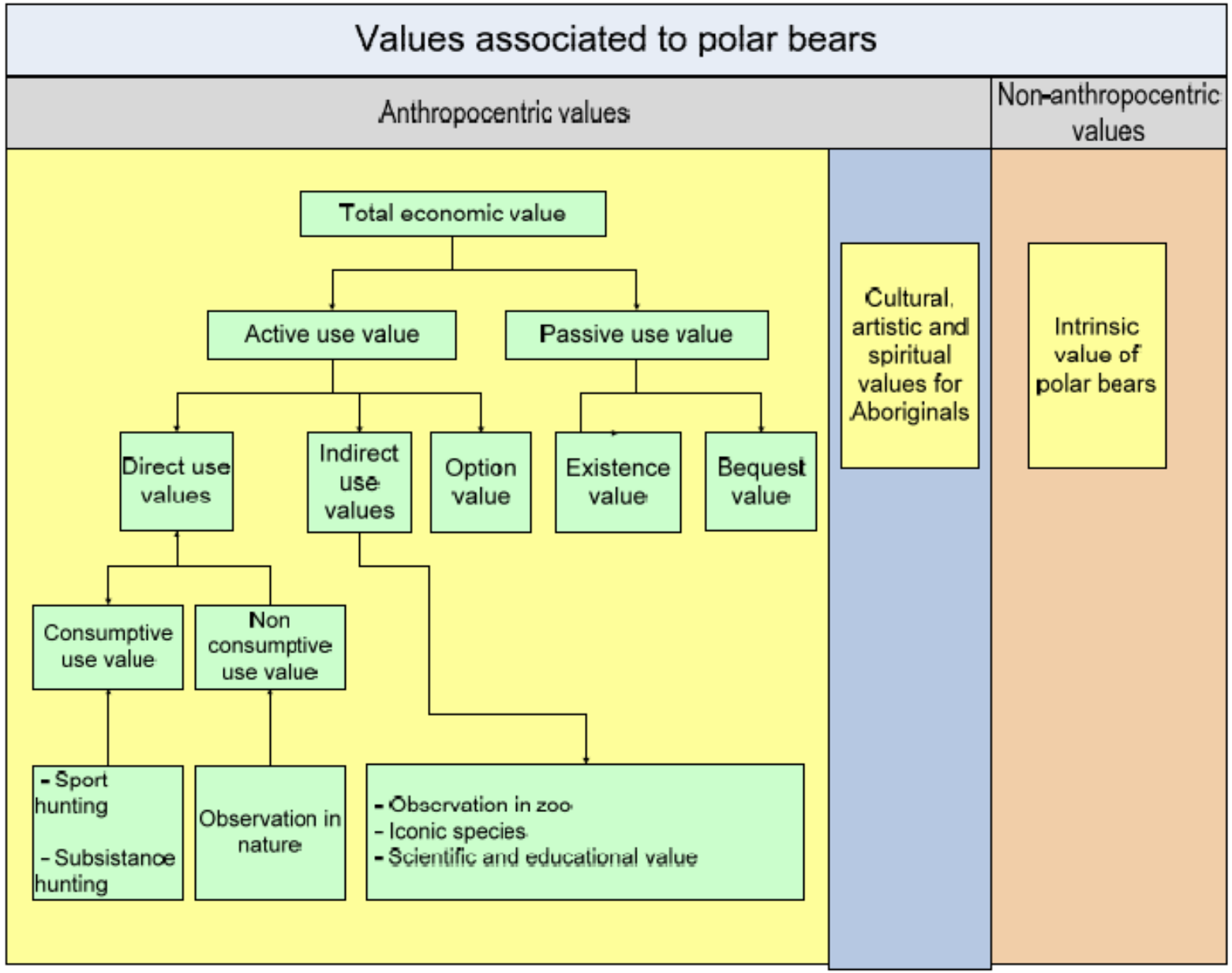
# An Example of an Environmental Benefits Assessment

A Canada study calculated that the benefits of the country's 15,000 polar bears at $6.3B annually (see full report).

Evidence of the Socio-Economic Importance of Polar Bears for Canada

Prepared by ÉcoRessources Consultants

FIGURE 1: VALUES ASSOCIATED WITH POLAR BEARS



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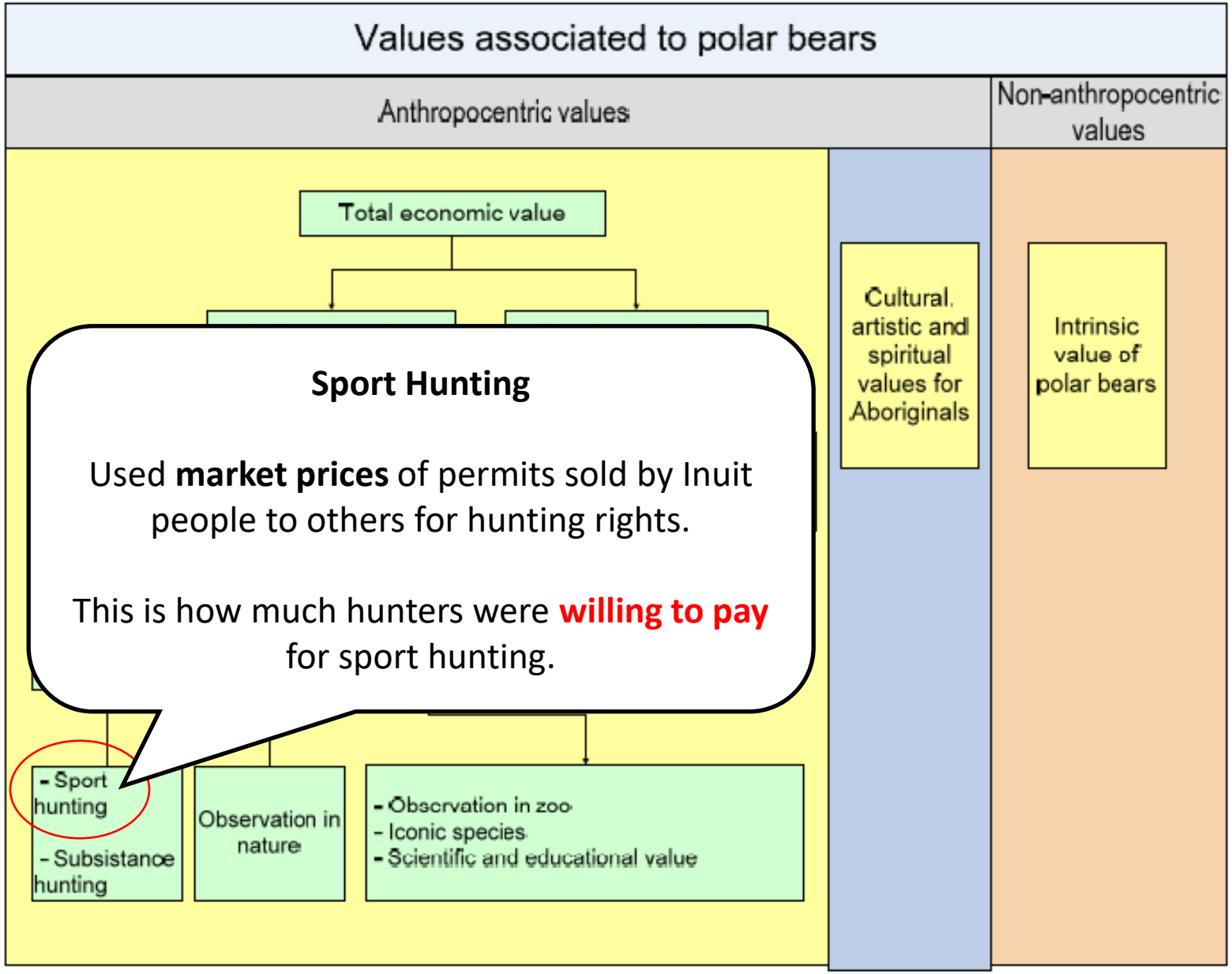


**Sport Hunting**

Used **market prices** of permits sold by Inuit people to others for hunting rights.

This is how much hunters were **willing to pay** for sport hunting.

Evidence of the Socio-Economic Importance of Polar Bears for Canada

Prepared by EcoRessources Consultants

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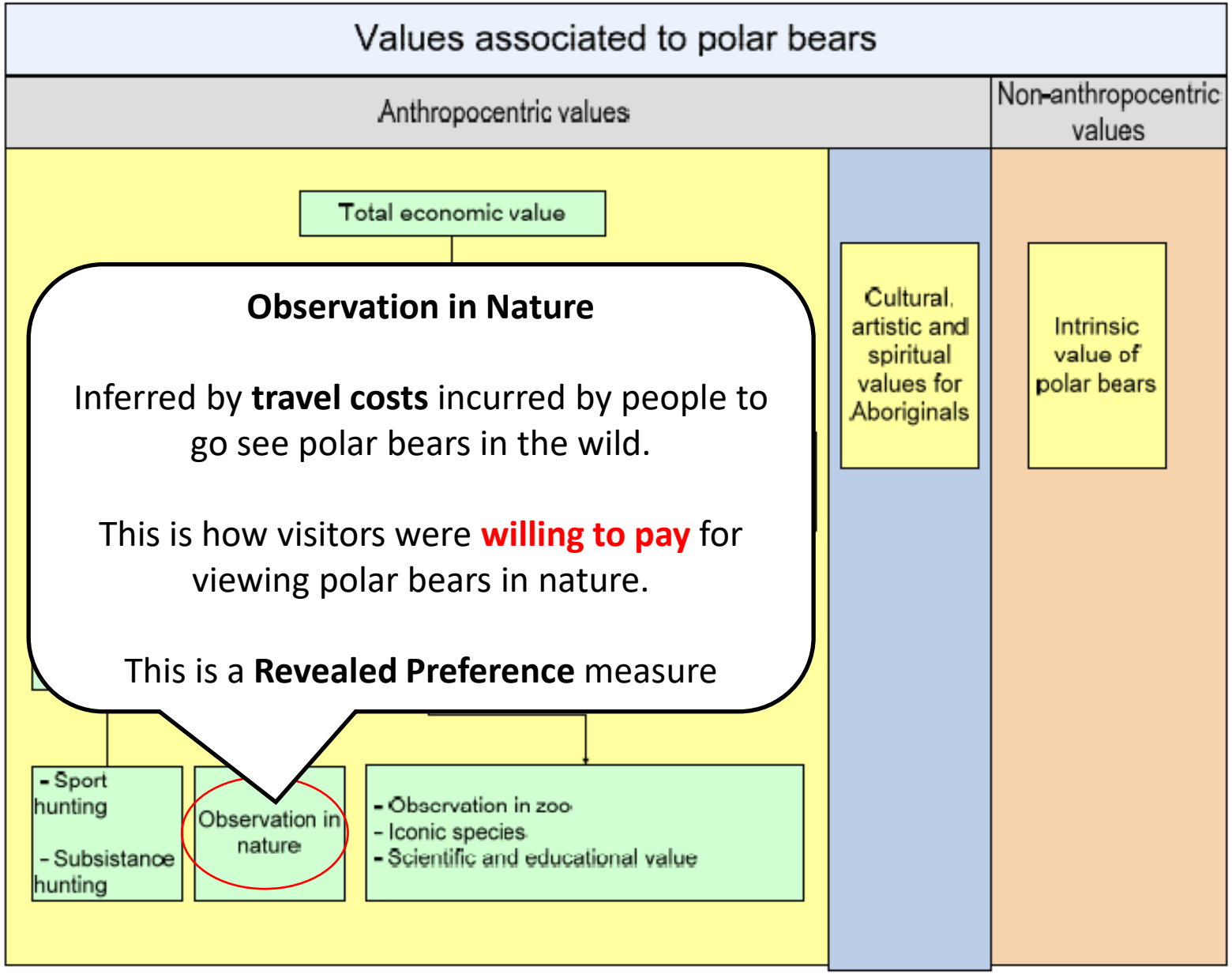


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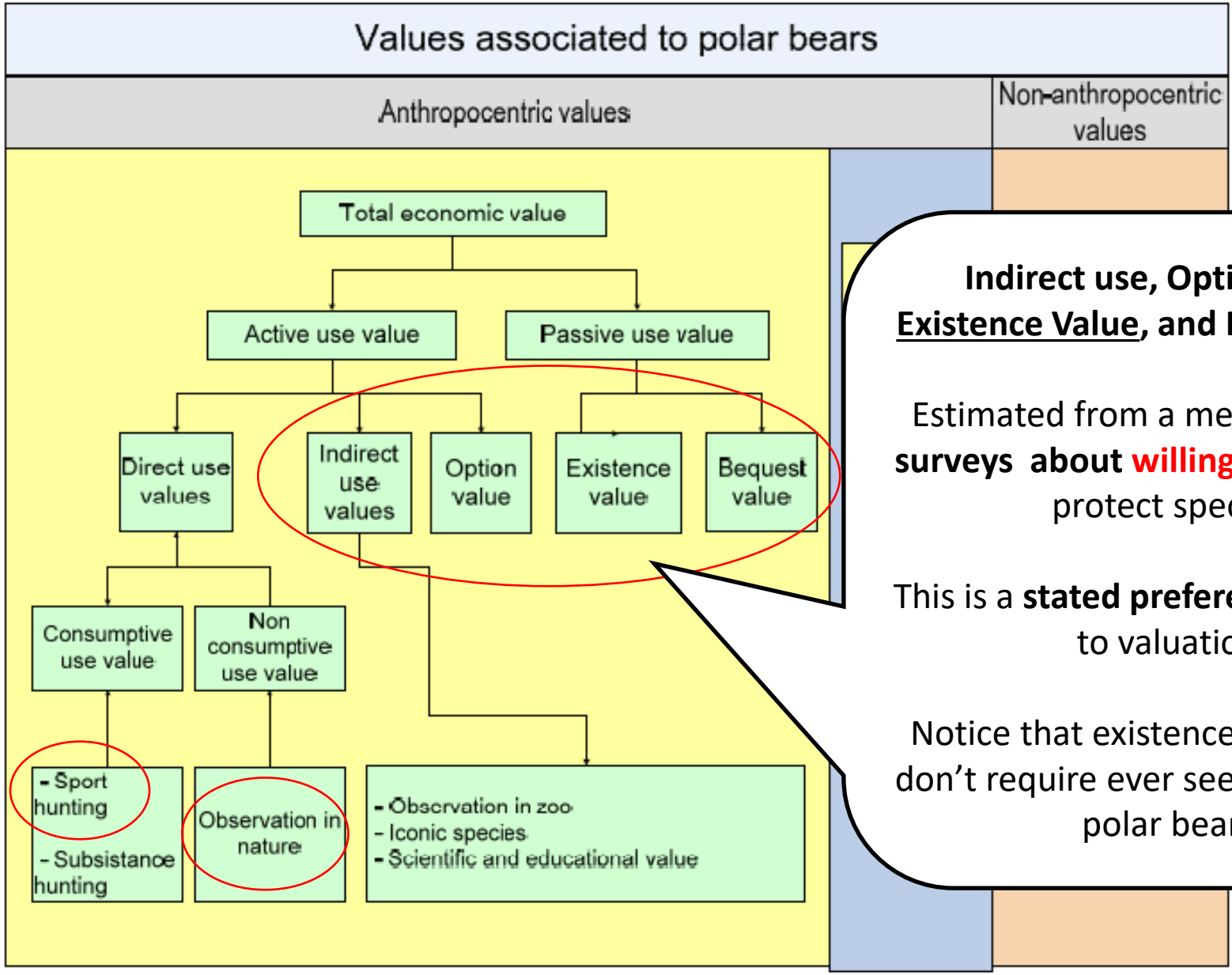



**Indirect use, Option Value, <u>Existence Value</u>, and Bequest Value**

Estimated from a meta-analysis of **surveys about willingness to pay** to protect species.

This is a **stated preference** approach to valuation.

Notice that existence and bequest don't require ever seeing or hunting polar bears.

omic Importance
r Canada

s Consultants

# Quick Aside

Polar bears are one of the only species on Earth to actively hunt humans.

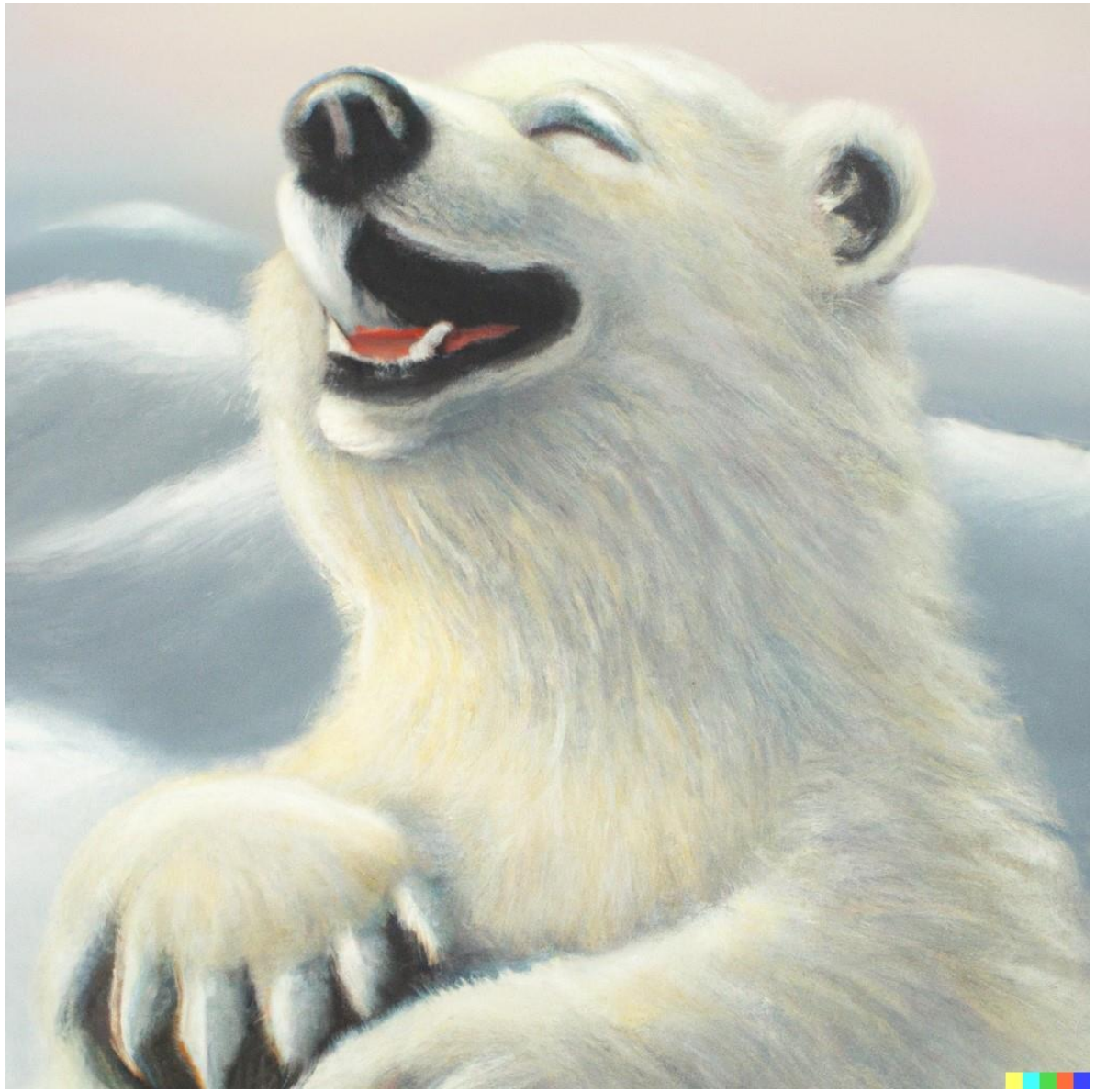
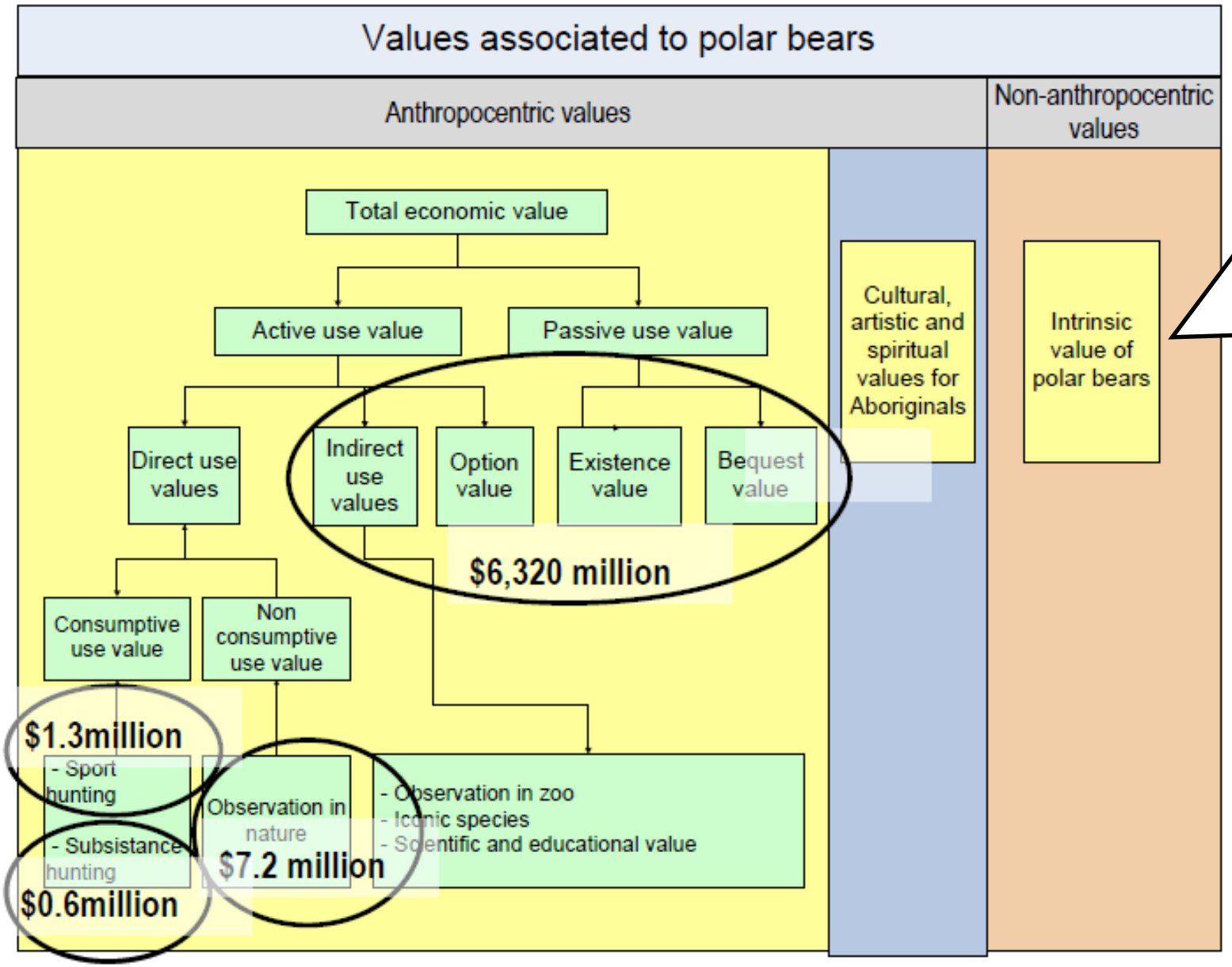


Image created using Dall-E. “Oil painting of a laughing polar bear.”

**FIGURE 2: MONETARY VALUES ASSOCIATED WITH POLAR BEARS IN CANADA, BY VALUE CATEGORY (AGGREGATE AMOUNTS FOR CANADA)**




**Intrinsic Value**

If polar bears were economists, what would they consider the intrinsic value of humans?

Evidence of the Socio-Economic Importance of Polar Bears for Canada

Prepared by EcoRessources Consultants

# How do we Measure Benefits?

Valuation of environmental goods is not always straightforward because environmental goods are not traded in a marketplace.

We've discussed many valuation methods thus far.

What about cost of illness?

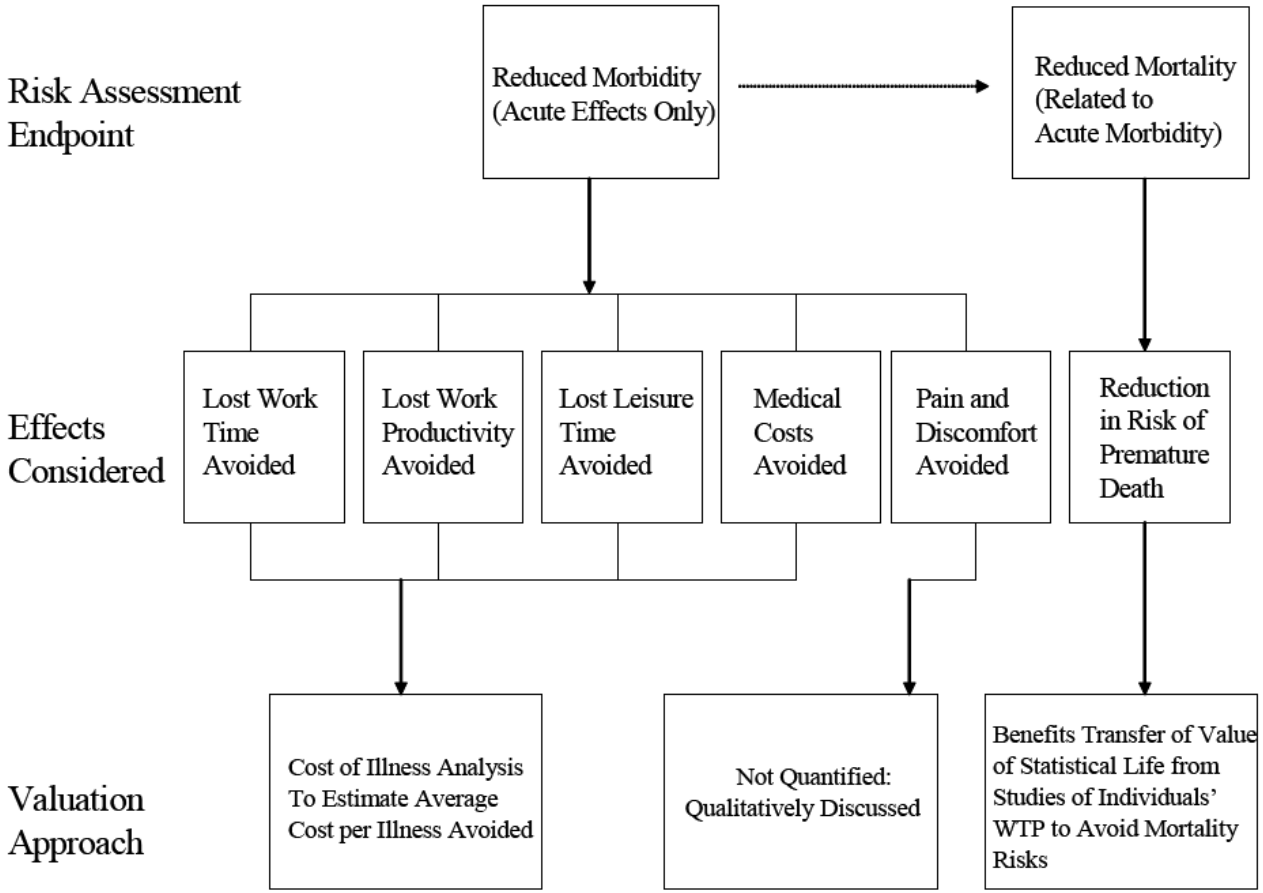
| Method | Examples | Types of Application |
|---|---|---|
| **Travel Cost** | Participation in recreation activity and site chosen | Recreation demand |
| **Hedonics** | Property purchased or choice of employment | Property value and wage models |
| **Defensive Behavior** | Expenditures to avoid illness or death | Morbidity / mortality |
| **Cost of Illness** | Expenditures to treat illness | Morbidity |

# Benefits of Avoided Illnesses

**Cost-of-Illness:** Benefits of reducing exposures to viral and bacterial contamination in drinking water with respect to cost of illness.

Cost of illness is not preference based. It is generally less than willingness to pay to avoid the illness.

**Exhibit 5.2 Overview of Viral Pathogen Risk Assessment and Benefits Valuation Procedure for Quantified Benefits (Main Analysis)[1]**




*Source: Economic Analysis for the Final Ground Water Rule, US EPA, 2006*

# How do we Measure Benefits?

We've discussed many valuation methods thus far.

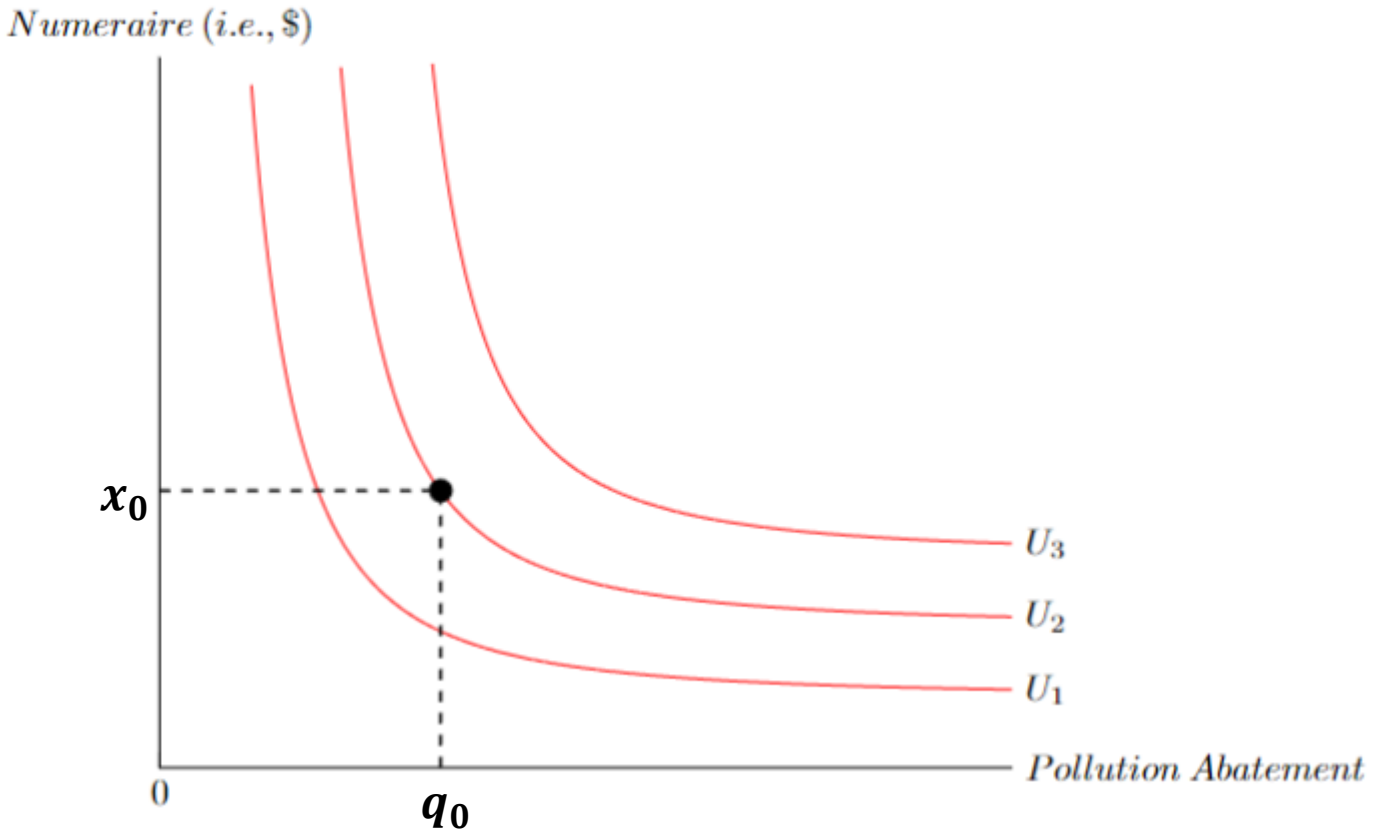
These quantification methods produce a willingness to pay measure.

| Method | Examples | Conceptual Framework | Types of Application |
|---|---|---|---|
| **Travel Cost** | Participation in recreation activity and site chosen | Household production, weak complementarity | Recreation demand |
| **Hedonics** | Property purchased or choice of employment | Demand for differentiated goods | Property value and wage models |
| **Defensive Behavior** | Expenditures to avoid illness or death | Household production, perfect substitutes | Morbidity / mortality |
| **Cost of Illness** | Expenditures to treat illness | Treatment costs | Morbidity |

# Willingness to Pay vs. Willingness to Accept

Willingness to pay (WTP): how much would a consumer pay for an environmental good they do not currently possess?

Willingness to accept (WTA): how much would a polluting firm have to compensate a consumer to make them indifferent to pollution exposure?




Willingness to accept vs. willingness to pay for a change in quantity of pollution abatement

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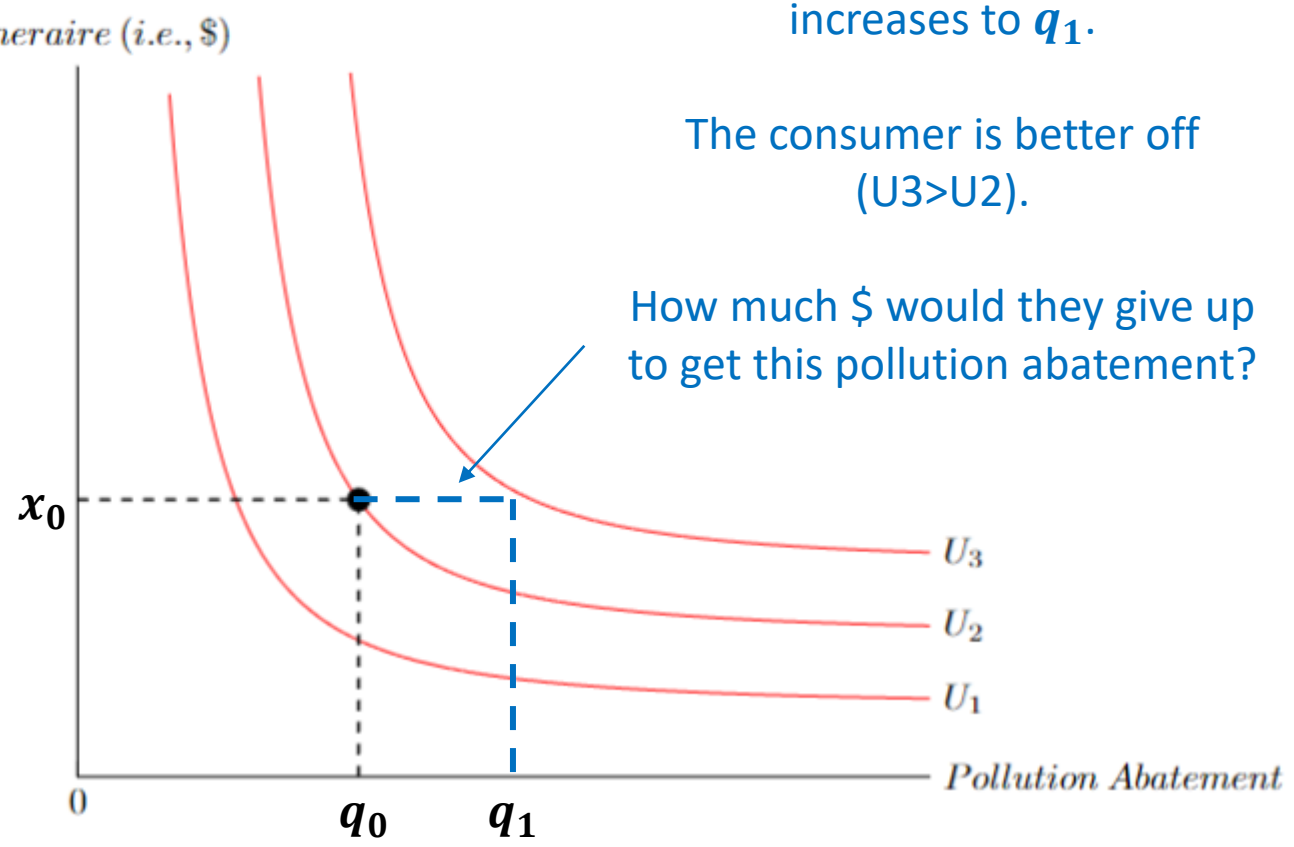
Willingness to accept (WTA): how much would a polluting firm have to compensate a consumer to make them indifferent to pollution exposure?

Suppose pollution abatement increases to $q_1$.

The consumer is better off (U3>U2).

How much $ would they give up to get this pollution abatement?

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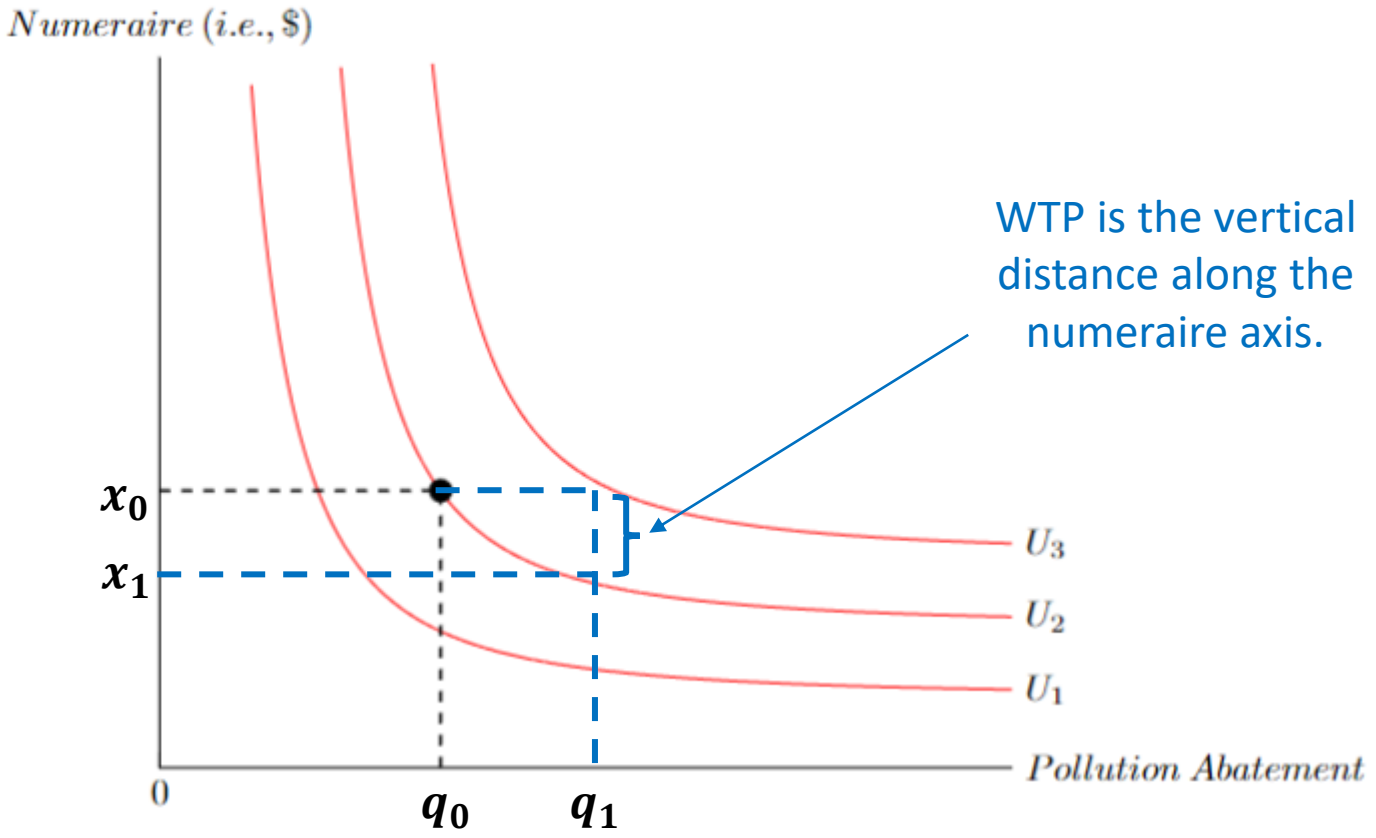


Willingness to accept vs. willingness to pay for a change in quantity of pollution abatement

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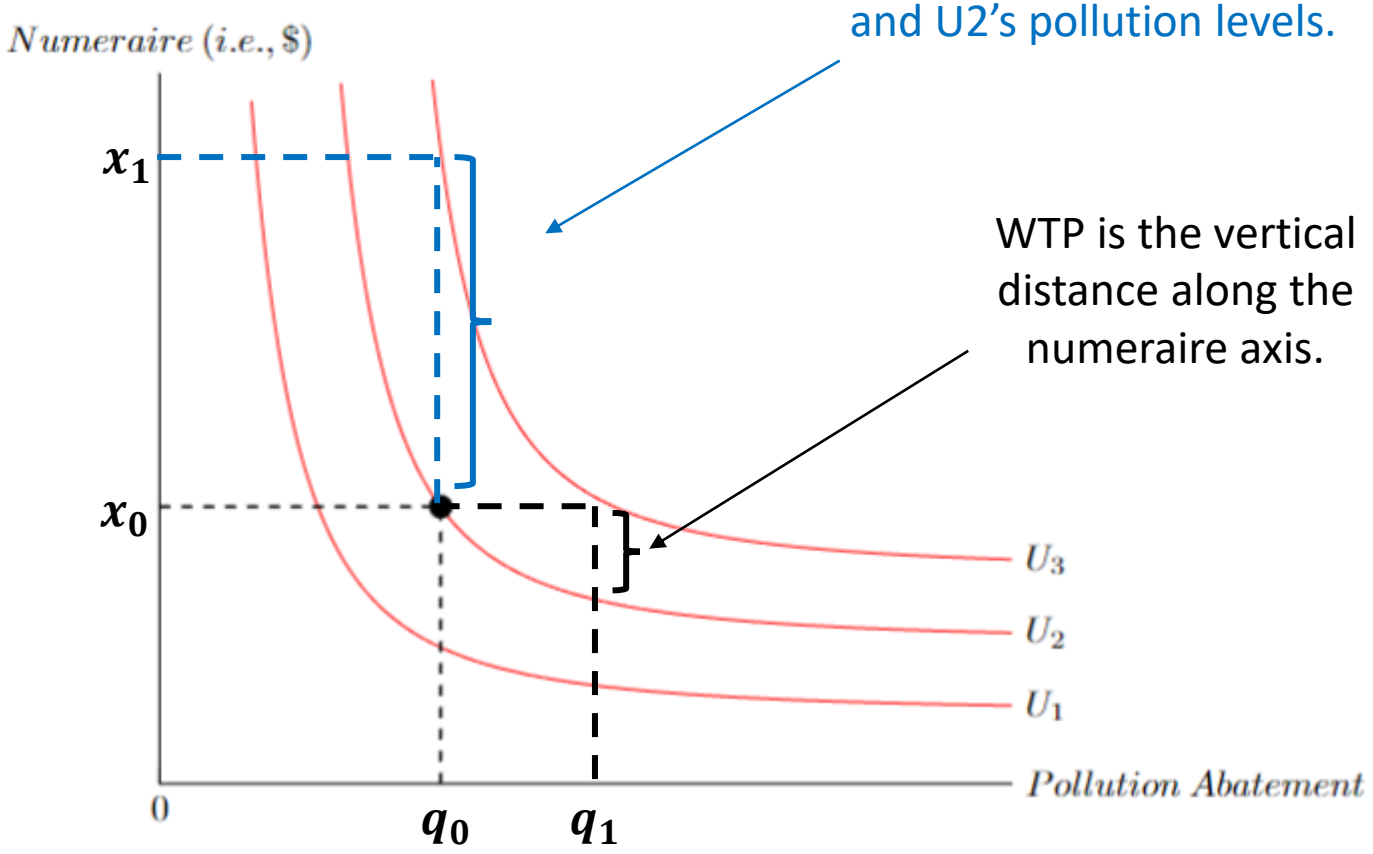
Willingness to pay (WTP): how much would a consumer pay for an environmental good they do not currently possess?

Willingness to accept (WTA): how much would a polluting firm have to compensate a consumer to make them indifferent to an amount of pollution exposure?

WTA is the $ amount this consumer would need to be indifferent between U3 and U2's pollution levels.

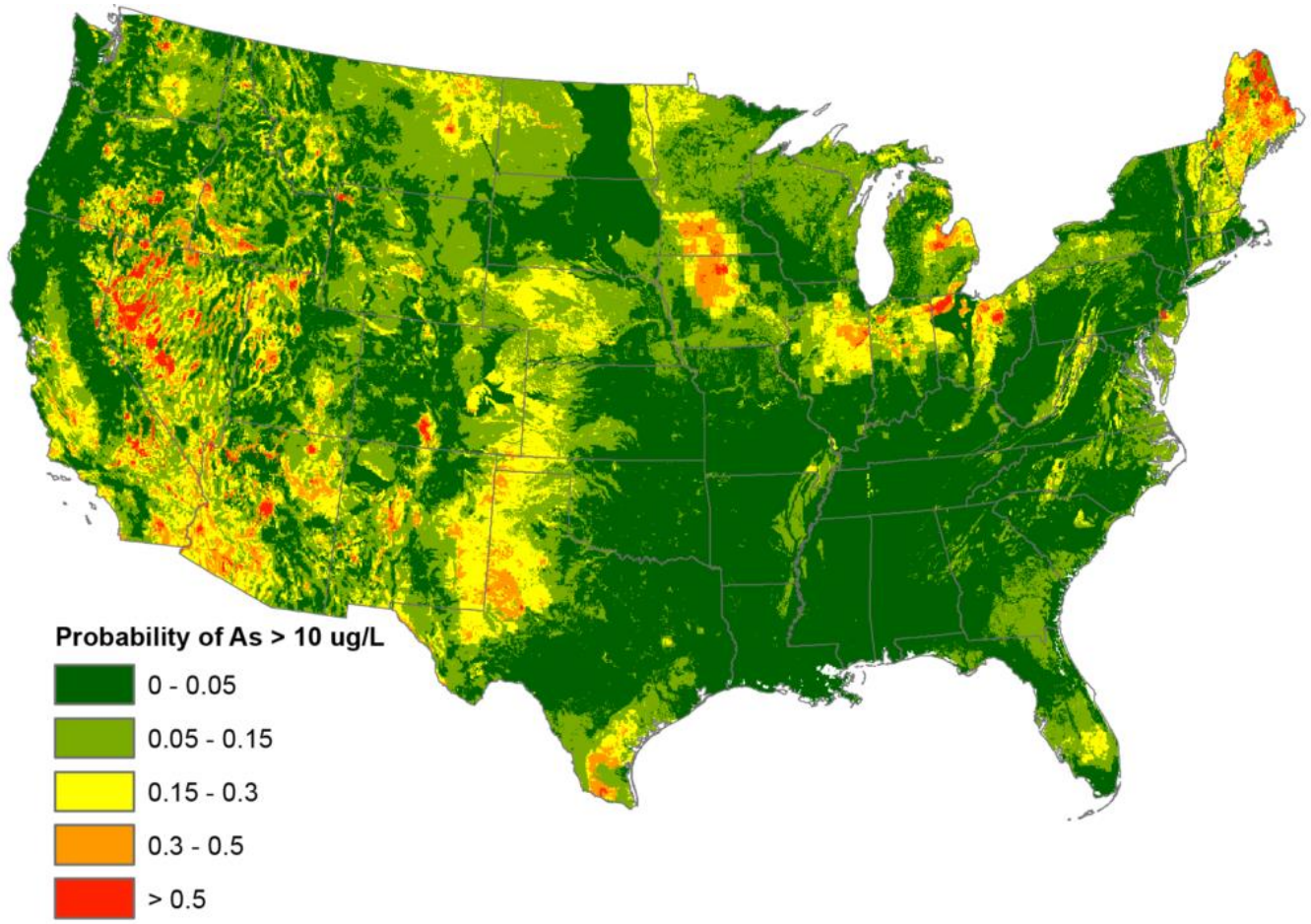
WTP is the vertical distance along the numeraire axis.




Willingness to accept vs. willingness to pay for a change in quantity of pollution abatement

# WTP v. WTA Example 1

A town gets its drinking water from groundwater wells. The area's bedrock has naturally-occurring arsenic. Some individuals buy more bottled water or home treatment devices to limit arsenic exposure.

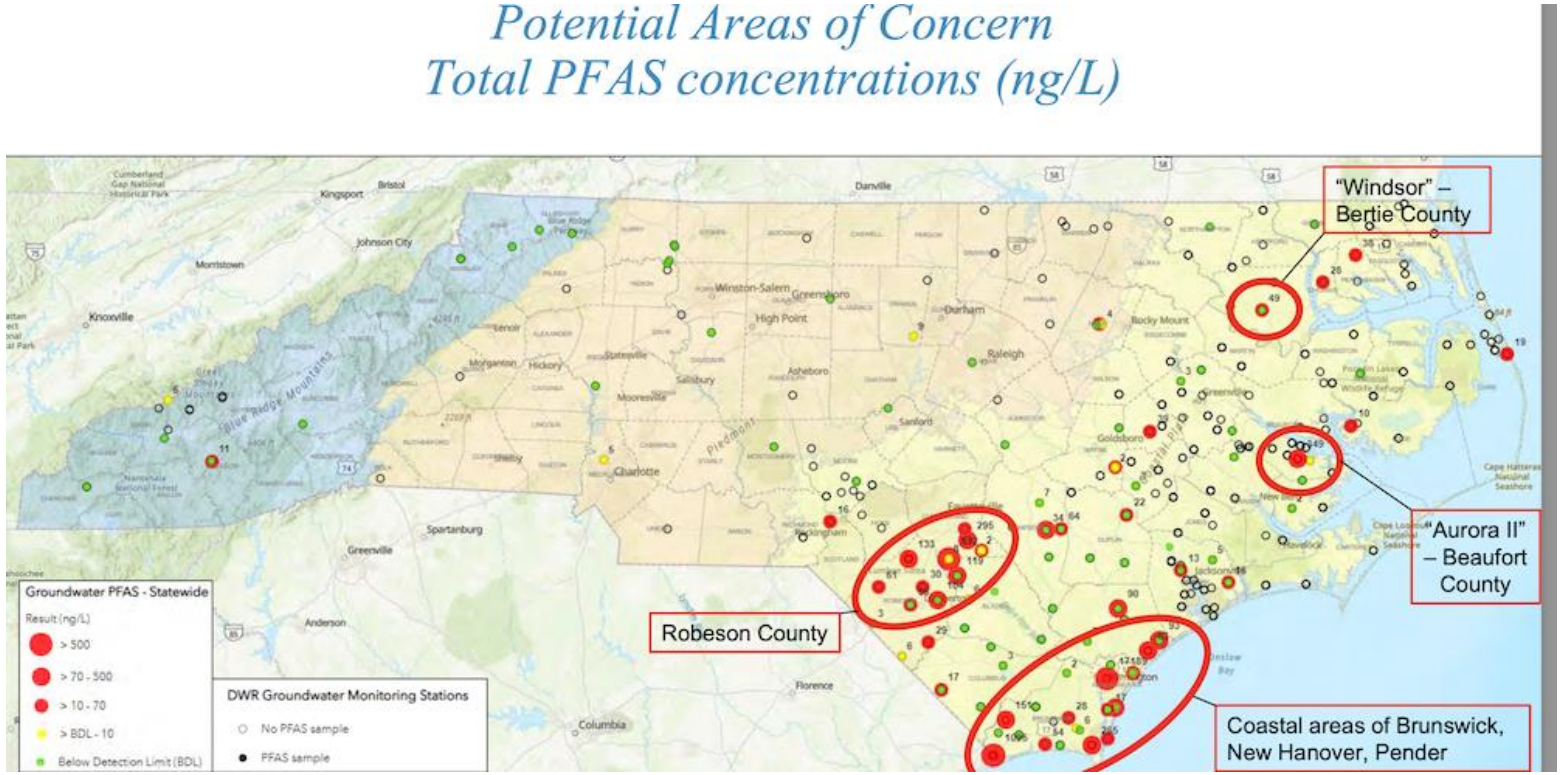



Arsenic in Groundwater across the US.

Source: US Geological Survey via PBS.

# WTP v. WTA Example 2

Suppose a town gets its water from the Cape Fear River, which has notable PFAS contamination from a Dupont-Chemours plant. The local population sues Dupont over the contamination.




Source: [North Carolina Department of Environmental Quality.]

# Willingness to Pay vs. Willingness to Accept

Suppose you need to value policies that aim to accomplish each of the following policy goals. What kind of metric (WTP or WTA) makes the most sense?

1. Building a bridge or a school.
2. Reduce exposure to Arsenic in groundwater.
3. Reduce exposure to PFAS in the Cape Fear River in North Carolina.
4. Reducing exposure to air pollution from the Gary Steel Plant.
5. Reducing exposure to wildfire air pollution.


Source: Wikipedia.

# Willingness to Pay vs. Willingness to Accept

In the above examples, you probably had an idea for which welfare measure makes the most sense to use. Use of WTP vs. WTA implies a value judgement on who has the right to pollute or the right not to be exposed to pollution.

Deciding who holds property rights over pollution is a value-based problem.

- WTP requires society to bribe a polluter to reduce pollution or to pay for the policy.
- WTA requires the firm to bribe the public until they are indifferent to the pollution.

# Willingness to Pay vs. Willingness to Accept

WTP and WTA in environmental benefit-cost analysis:

- In principle we should match WTP or WTA with the policy question
  - Are you being asked to pay for an improvement?
  - Is it a decrement where WTA would be the more applicable concept?
- Some economists suggest WTP should be the measure because WTP is bound by income.
- WTP is more often measured in empirical analyses (e.g., stated preference).
- Studies have frequently shown that WTA is 7-10x larger than WTP (Tuncel and Hammitt 2014).

Most economic analyses use measures of willingness to pay rather than willingness to accept.

# Cost Categories

Costs include those to firms, consumers, state and local governments, and in some cases members of the public who must read new rules.

- Capital costs
  - Installing new compliance technologies
- Labor Costs
  - Companies hiring new workers to install compliance technologies
  - State governments reading new regulations and enforcing them
  - Legal costs
- Operation and Maintenance costs
  - Electricity and ongoing labor for pollution abatement
  - Lost time

# How do we Measure Costs?

The costs are typically estimated by survey where firms are asked their compliance costs.

In some cases, engineering models need to be applied given complexity of abatement technologies.

TABLE 5

Cost elements included in all work breakdown structure models

| Cost category | Components included | |
|---|---|---|
| Total capital costs | | |
| Direct capital costs | • Technology-specific equipment (e.g., vessels, basins, pumps, blowers, treatment media, piping, valves) | • Instrumentation and system controls<br>• Buildings<br>• Residuals management equipment |
| Add-on costs | • Land<br>• Permits | • Pilot testing |
| Indirect capital costs | • Mobilization and demobilization<br>• Architectural fees for treatment building<br>• Equipment delivery, equipment installation, and contractor's overhead and profit<br>• Sitework<br>• Yard piping<br>• Geotechnical<br>• Standby power | • Electrical infrastructure<br>• Process engineering<br>• Contingency<br>• Miscellaneous allowance<br>• Legal, fiscal, and administrative<br>• Sales tax<br>• Financing during construction<br>• Construction management and general contractor overhead |
| • Operations and maintenance costs | | |
| Labor | • Operator labor for operation and maintenance of process equipment<br>• Operator labor for building maintenance<br>• Managerial and clerical labor | • Operator labor for other technology-specific tasks (e.g., managing regeneration, backwash, or media replacement) |
| Materials | • Materials for maintenance of booster or influent pumps<br>• Materials for building maintenance<br>• Materials for maintenance and operation of technology-specific equipment | • Replacement of technology-specific consumables (e.g., chemicals) or other frequently replaced items (e.g., treatment media) |
| Energy | • Energy for operation of booster or influent pumps<br>• Energy for lighting, ventilation, cooling, and heating | • Energy for operation of technology-specific items of equipment (e.g., blowers, mixers) |
| Residuals | • Residuals management operator labor, materials, and energy | • Residuals discharge and disposal costs (including transportation) |

Source: Cost elements included in an analysis of the costs of treating nitrates in drinking water (see Khera et al. 2021).

# An Example Engineering Cost Model

A Work Breakdown Structure model for reverse osmosis and nanofiltration.

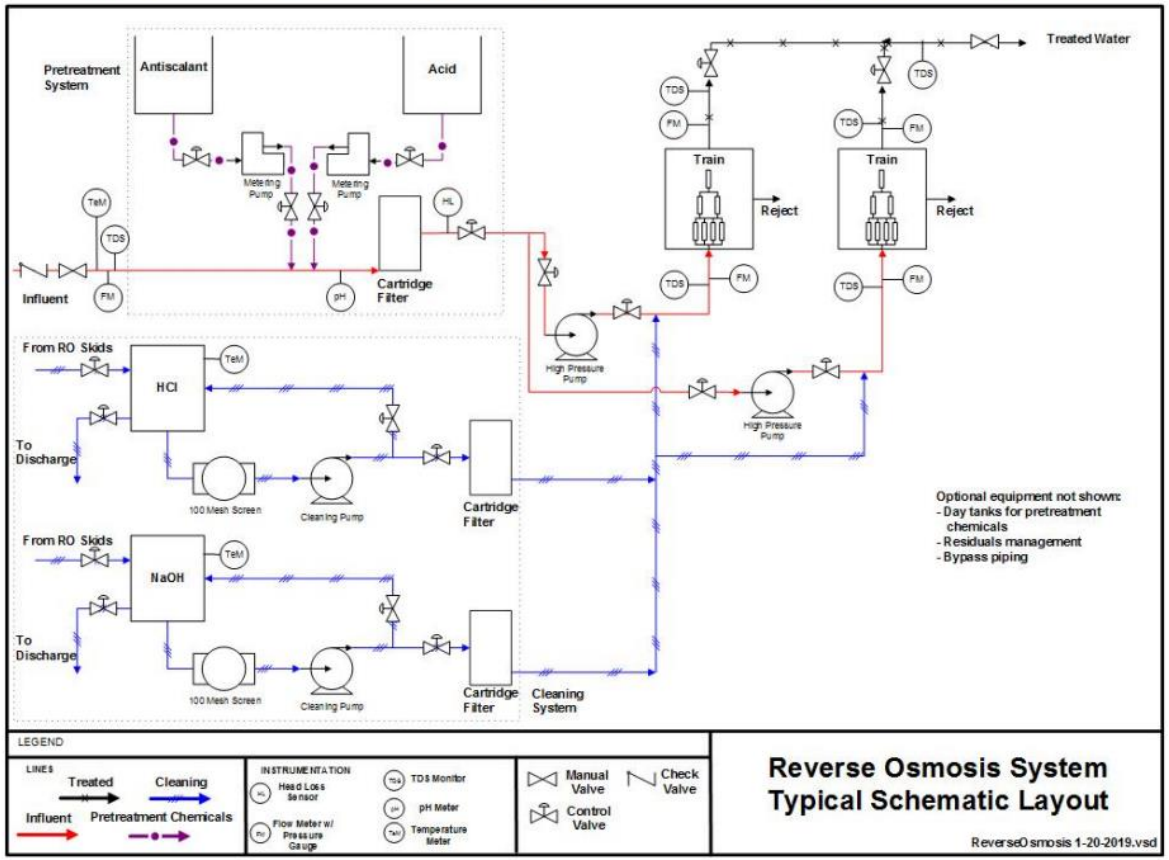
**Exhibit 2-9. Sample of Index Spreadsheet**

INDEX

This page provides an index to all user-adjustable inputs and assumptions. Click on a variable name to go directly to the adjustable cells.

| User-adjustable Input or Assumption | Variable Name and Link |
|---|---|
| Access space per pump/blower for custom designed systems | space_pumps_cust |
| Access space per pump/blower for pre-engineered packages | space_pumps_pre |
| Additional blower head above water depth | add_blow_head |
| Additional building after… | add_2nd_building |
| Administrative LOE as a percent of average technical labor | Clerical_percent |
| Air conditioning EER | EER |
| Air to water ratio | air_water_ratio |
| Always include NEPA compliance costs? | include_NEPA |
| Annual cooling degree days | cool_DD |
| Annual heating degree days | heat_DD |
| Average Flow | average_flow_l |

**Exhibit 3-2. Typical Schematic Layout for Reverse Osmosis/Nanofiltration**



# Are Cost Estimates Accurate?

Engineering cost models for drinking water treatment are off by -30% to 50% (Price and Heberling, 2018).

Cost analyses can be biased for many other reasons as well.

**Table 1** Reasons proposed in the literature for cost misestimation ex ante

| Possible reason | Example(s) | Direction of bias ex ante | Sources |
|---|---|---|---|
| Regulators' approach to cost estimation | Conservative (or optimistic) cost assumptions, less effort when benefits greatly exceed costs | Either | Harrington, Morgenstern, and Nelson 2000; Hahn 2004; Simpson 2014 |
| Long promulgation process | Changes in exogenous factors, cheaper compliance options than analyzed | Either | Harrington, Morgenstern, and Nelson 2000; Simpson 2014; Morgenstern 2018 |
| Inadequate consideration of technological innovation | Technologies in development that lower costs relative to those already known/in use, learning by doing | Mainly overestimated | Harrington, Morgenstern, and Nelson 2000; Simpson 2014; Morgenstern 2018 |
| Unaccounted-for costs | Behavioral change, opportunity costs, and short-run adjustment costs; uncertainty in sources of pollution or effectiveness of abatement strategies | Mainly underestimated | Harrington, Morgenstern, and Nelson 2000; Hahn 2004; Morgenstern 2018 |
| Misspecified baseline | Failure to account for state regulation or exogenous factors that affect future production, prices, and demand; uncertainty on which control measures are in place | Either | Harrington, Morgenstern, and Nelson 2000; Simpson 2014; Morgenstern 2018 |
| Compliance errors | Less effective rule than expected | Either | Harrington, Morgenstern, and Nelson 2000; Simpson 2014; Morgenstern 2018 |

Source: Fraas et al. (2023)

# Part 2: How to Conduct a BCA

# The General Framework – Arrow et al. (1996)

Costs of all federal regulations in 1996 was $200B. Cost effectiveness analysis shows that regulations cost anywhere from $200,000 to $6.3 trillion per life saved.

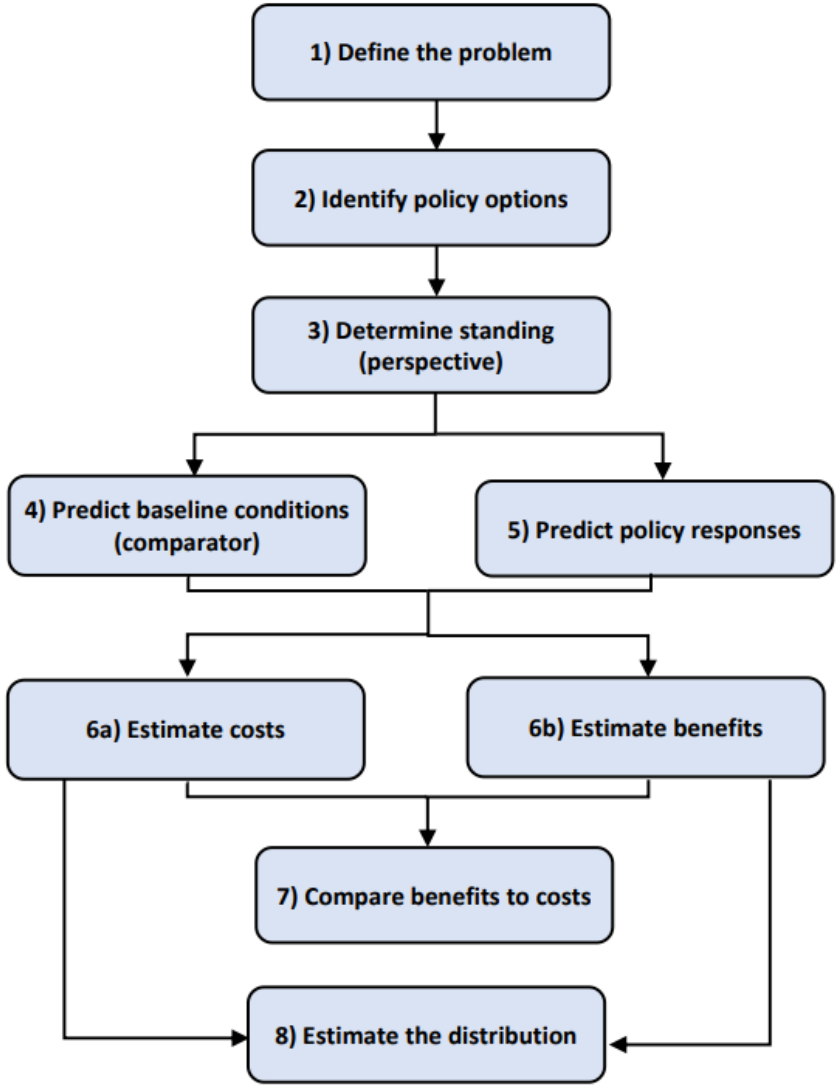
1) Benefit cost analysis helps elucidate the pros and cons of a policy choice.
2) Laws should not be written to prevent the possibility of considering BCA.
3) BCA should be required for all "major" policies.
4) Agencies should explain why they make decisions that go against BCA but should not be bound by specific benefit-cost tests.
5) BCAs should quantify all benefits and costs if possible.
6) BCAs should provide more external peer review.
7) BCAs should rely on a consistent set of economic assumptions.
8) BCAs should consider distributional consequences.

**Is There a Role for Benefit-Cost Analysis in Environmental, Health, and Safety Regulation?**

Kenneth J. Arrow, Maureen L. Cropper, George C. Eads, Robert W. Hahn, Lester B. Lave, Roger G. Noll, Paul R. Portney, Milton Russell, Richard Schmalensee, V. Kerry Smith, and Robert N. Stavins

# Key Steps

A good BCA should identify several potential policy options including no policy.




Reference Case Guidelines for Benefit-Cost Analysis in Global Health and Development

Lisa A. Robinson, James K. Hammitt, Michele Cecchini, Kalipso Chalkidou, Karl Claxton, Maureen Cropper, Patrick Hoang-Vu Eozenou, David de Ferranti, Anil B. Deolalikar, Frederico Guanais, Dean T. Jamison, Soonman Kwon, Jeremy A. Lauer, Lucy O'Keeffe, Damian Walker, Dale Whittington, Thomas Wilkinson, David Wilson, and Brad Wong*

May 2019

Funded by the Bill & Melinda Gates Foundation

* The views expressed in this document are solely those of the authors, and do not necessarily reflect the views of the organizations with which they are affiliated or their membership.

Source: Guidelines on preparing BCA by Lisa Robinson et al (2019).

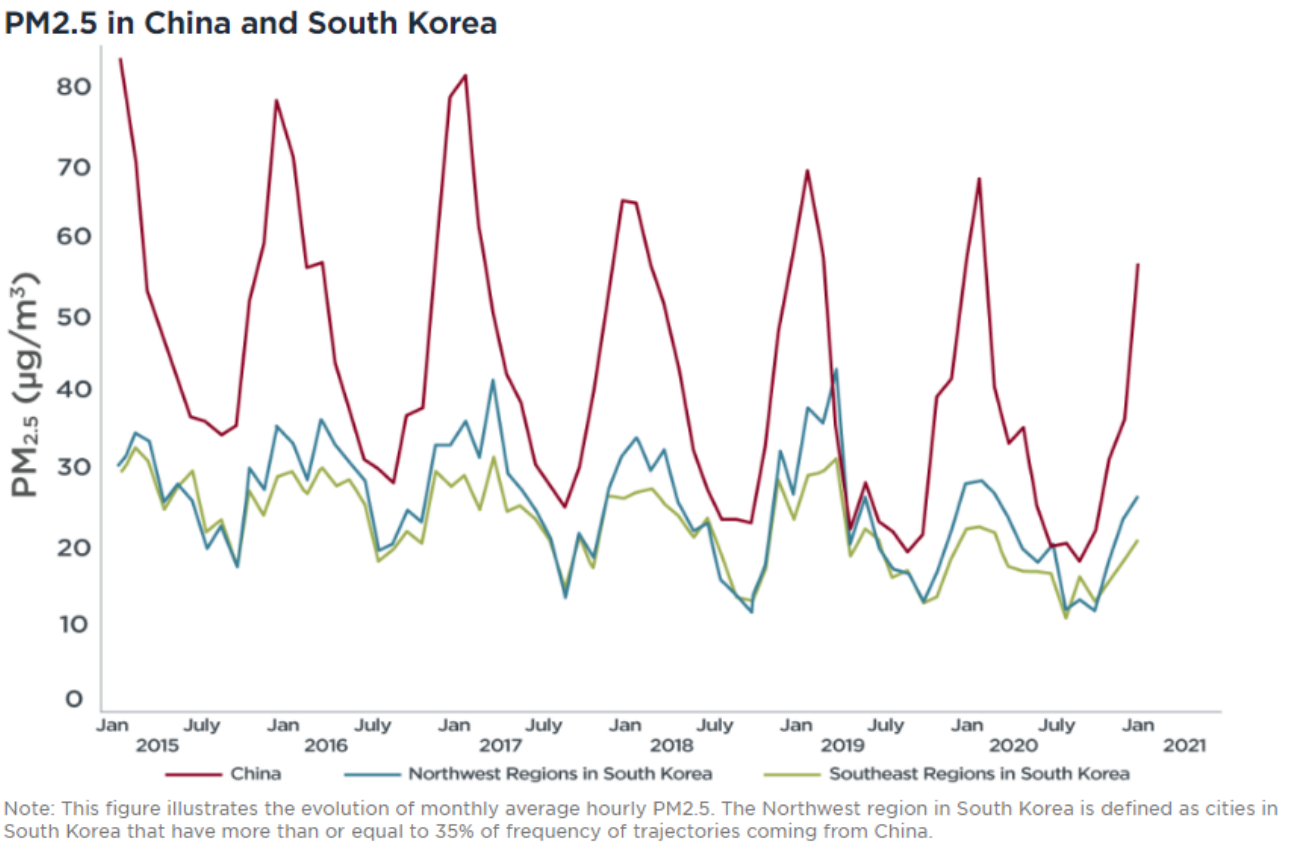
# Determining Standing

Determining “Standing” for an environmental BCA is deciding whose benefits and costs count.

- Jurisdictions
- Future generations

Standing is often informed by legal considerations.

**China’s Pollution Spills Over to South Korea, as Does the Benefits of its Policies**




Note: This figure illustrates the evolution of monthly average hourly PM2.5. The Northwest region in South Korea is defined as cities in South Korea that have more than or equal to 35% of frequency of trajectories coming from China.

Source: Energy Policy Institute at the University of Chicago (2023).

# An Example for Standing – Climate Change

The draft Social Cost of Greenhouse Gases report incorporates new climate science and increases per ton CO2e damages from $50 to $190.

- "It is the only federal rule that explicitly puts a value on the lives of non-Americans, and considers the benefits to them of abating climate change."

### 1.3 Accounting for Global Damages

Benefit-cost analyses of U.S. Federal regulations have traditionally focused on the benefits and costs that accrue to individuals that reside within the country's national boundaries and that accrue to regulated industries, regardless of the nationality of the owners of affected physical assets.[15] This approach reflects the fact that for most regulations, those are the two groups primarily affected. It does not reflect any other scientific, legal, or other rationale. The default recommendation in OMB's Circular A-4 (2003) is that, an "analysis should focus on benefits and costs that accrue to citizens and residents of the United States."[16] However, OMB Circular A-4 states that when a regulation is likely to have international effects, "these effects should be reported"; and though the guidance recommends this be done separately, the guidance also explains that "[d]ifferent regulations may call for different emphases in the analysis, depending on the nature and complexity of the regulatory issues."[17] The National Academies advised that "[i]t is important to consider what constitutes a domestic impact in the case of a global pollutant that could have international implications that affect the United States" (National Academies 2017, p. 13). There are many reasons, as summarized in this section – and as articulated by OMB and in IWG TSDs (IWG 2010, 2013, 2016a, 2016b, 2021) and the 2015 Response to Comments (IWG 2015) – why the EPA uses the global value of climate change impacts when analyzing policies that affect GHG emissions, which have global effects. Courts have upheld the use of global estimates of the SC-GHG, partially in recognition of

# An Example for Standing – Climate Change

The draft Social Cost of Greenhouse Gases report incorporates new climate science and increases per ton CO2e damages from $50 to 190.

- "EPA has chosen to weigh the mortality costs of climate change in proportion to per capita income of the country where someone dies… A German life is worth 12 Cambodian lives."

**The tricky business of putting a dollar value on a human life**

The EPA's draft "social cost of carbon" analysis opens up a knotty discussion about US lives versus lives abroad.

By Dylan Matthews | dylan@vox.com | Dec 22, 2022, 7:30am EST

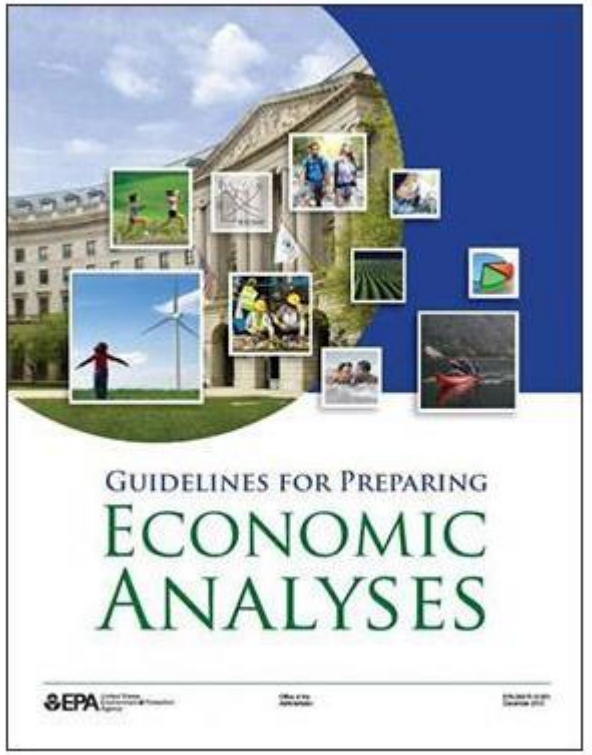
Source: VOX, The tricky business of putting a dollar value on a human life

# The Baseline

The converse of the policy alternatives is the baseline. The baseline is what the world would be like if you did not implement the policy. The policy case is the world with the policy.

From the EPA Guidelines for Economic Analyses:

> *The baseline scenario describes the expected **future extent of the environmental problem** and level of environmental contaminants along with the affected markets and exposed population in the absence of the proposed regulation. While the policy scenario is described in a similar fashion to the baseline, it reflects different environmental and/or market conditions as well as the expected compliance activities to comply with the policy.*

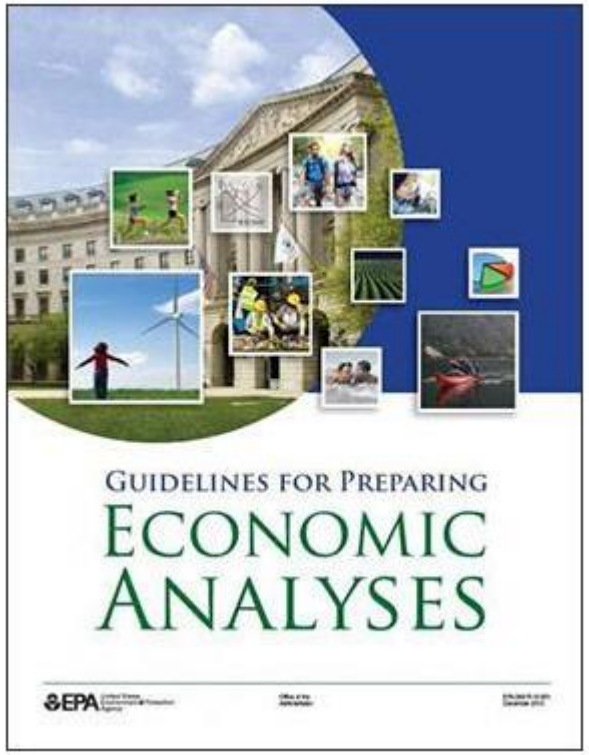


# What is the Purpose of a Baseline?

Suppose you are conducting a benefit-cost analysis for some set of policy options, then you need a reference scenario against which you are measuring the costs and benefits.

- You don't want to compare the "world before" and the "world after" the policy. Many things will likely change.
- You need a world "with the policy" and a "world without the policy."

***Both benefits and costs must be estimated using <u>exactly</u> the same baseline assumptions in the baseline and policy scenarios***.



# How does one construct a baseline?

Current period

- Current environmental problem
- Affected markets, consumers, governments

- Demographic changes
- Regulatory changes
- Technological changes
- Consumer behavioral changes
- Others?

Future period – No regulation

Future period – Regulation

# Comparing the Baseline to the Policy Scenario

Current period

- Current environmental problem
- Affected markets, consumers, governments

- Benefits = baseline value of damages – policy valuation of damages
- Costs = all costs of the policy
- Net benefits = benefits – costs
- Distributional Impacts = (baseline differences in exposure) – (policy differences in exposure)

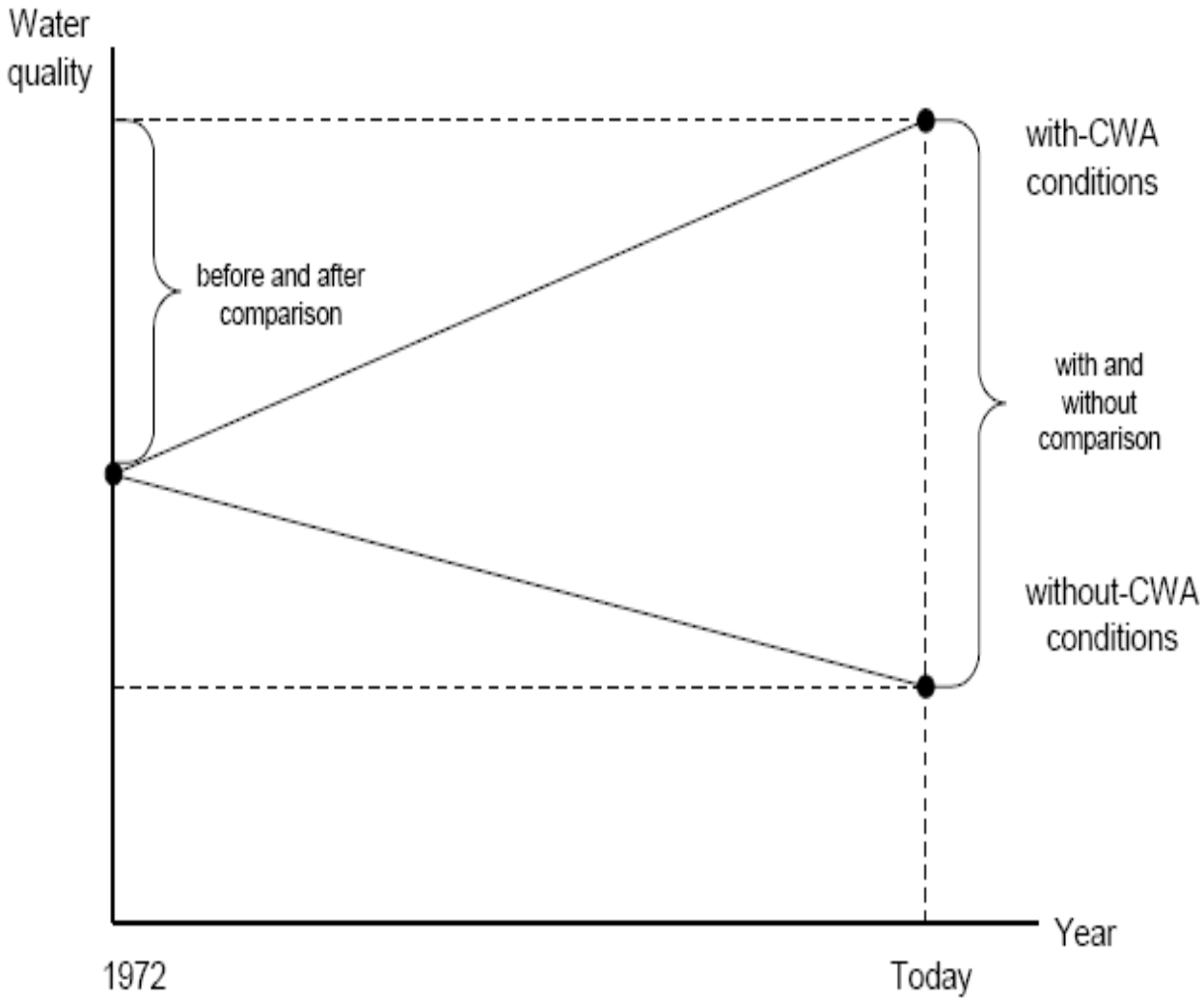
Future period – No regulation

Future period – Regulation

# Comparing Policy Case to Baseline

Retrospective BCA of the Clean Water Act

Illustration of how comparison of the baseline to the policy scenario is not the same as before vs. after



# Part 3: Limitations of BCA

# Common Sense

Sometimes conducting a BCA over a particular government action may not be the best use of resources.

Some examples:

- A legislative or legal action already requires that the government act in a certain way.
- The costs of conducting a BCA are less than the plausible costs of the policy itself.
- Ethical considerations can make BCA seem ludicrous, even reprehensible.
  - See Heinzerling (2012) Cost Benefit Jumps the Shark.

Lisa Heinzerling, Georgetown Law Professor, former head of EPA's Office of Policy, and occasional critic of BCA.

# The Infamous Senior Death Discount

In 2003, the EPA considered adjusting the VSL from $6.1m in then dollars to $2.3m for citizens over 70.

- The move was dubbed the “senior death discount.”
- Critics suggested the administration was turning on older Americans to weaken environmental regulations.
  - Reduced benefits of some regulations by 90%.

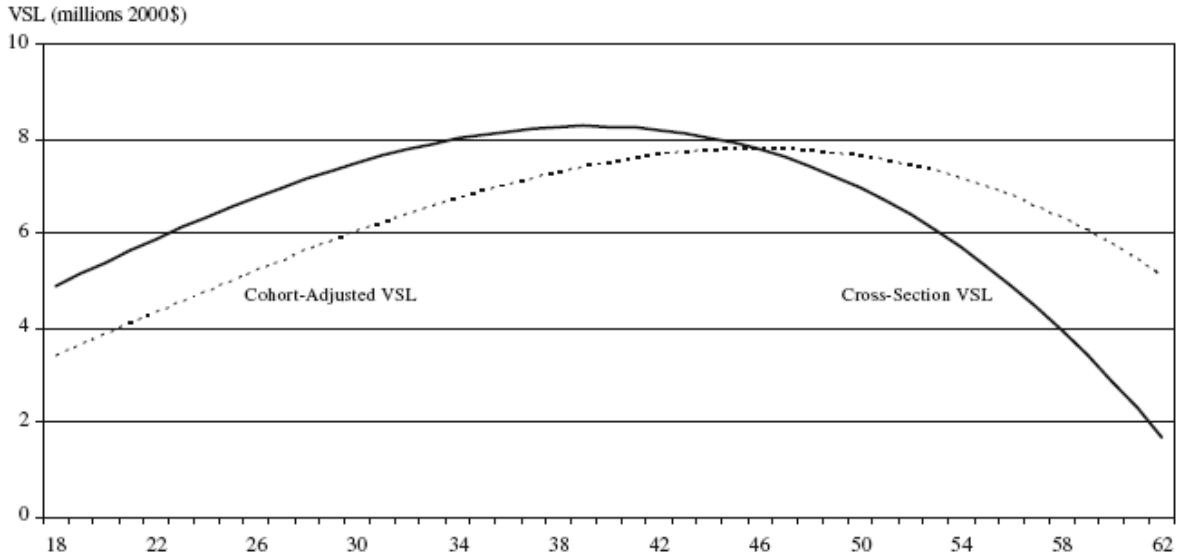
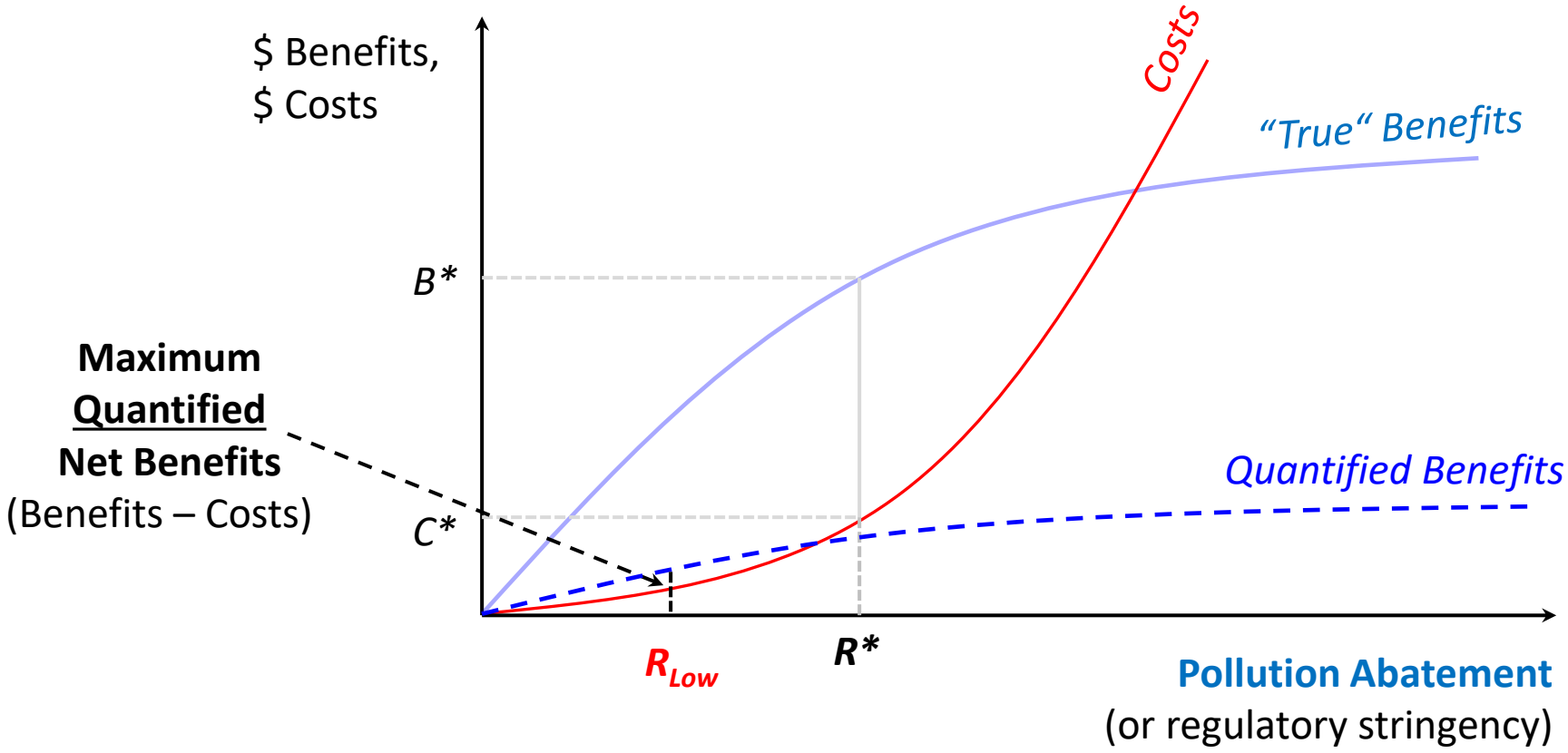




**Fig. 1** Cohort-adjusted and cross-section value of statistical life, 1993–2000. Source: Aldy and Viscusi (2008)

Source: Aldy and Viscusi (2008).

# Unobserved and Unquantified Benefits



# Uncertain Benefits, More Certain Costs

Cost information is often provided directly by firms.

- Firms have an incentive to know their exact cost function, to research potential uncertainties around costs, and to know all ways in which a regulation impacts them.
  - Firms have an expert understanding of their costs.
- Firms also have an incentive to over-state the true costs of regulation (Kopits et al., 2015).

The public faces a coordination problem in assessing the true benefits of a policy.

- A role for academics and think tanks in filling this gap, but unfortunately there is a mismatch in funding and resources to accurately assess society's costs and benefits.
  - The public often does not know their true benefits.

# The Cost-Benefit Fallacy: Why Cost-Benefit Analysis Is Broken and How to Fix It (here)

By: Bent Flyvbjerg and Dirk W. Bester

**Abstract:** Most cost-benefit analyses assume that the estimates of costs and benefits are more or less accurate and unbiased. **But what if, in reality, estimates are highly inaccurate and biased? Then the assumption that cost-benefit analysis is a rational way to improve resource allocation would be a fallacy.** Based on the largest dataset of its kind, we test the assumption that cost and benefit estimates of public investments are accurate and unbiased. We find this is not the case with overwhelming statistical significance. We document the extent of cost overruns, benefit shortfalls, and forecasting bias in public investments. We further assess whether such inaccuracies seriously distort effective resource allocation, which is found to be the case. We explain our findings in behavioral terms and explore their policy implications. Finally, we conclude that cost-benefit analysis of public investments stands in need of reform and we outline four steps to such reform.

# The Cost-Benefit Fallacy: Why Cost-Benefit Analysis Is Broken and How to Fix It (here)

By: Bent Flyvbjerg and Dirk W. Bester

| Investment type | Cost overrun (A/E) | | | Benefit overrun (A/E) | | | p** |
|---|---|---|---|---|---|---|---|
| | N | Average | p* | N | Average | p* | |
| Dams | 243 | 1.96 | < 0.0001 | 84 | 0.89 | < 0.0001 | <0.0001 |
| BRT† | 6 | 1.41 | 0.031 | 4 | 0.42 | 0.12 | 0.007 |
| Rail | 264 | 1.40 | < 0.0001 | 74 | 0.66 | < 0.0001 | <0.0001 |
| Tunnels | 48 | 1.36 | < 0.0001 | 23 | 0.81 | 0.03 | 0.015 |
| Power plants | 100 | 1.36 | 0.0076 | 23 | 0.94 | 0.11 | 0.0003 |
| Buildings | 24 | 1.36 | 0.00087 | 20 | 0.99 | 0.77 | 0.01 |
| Bridges | 49 | 1.32 | 0.00012 | 26 | 0.96 | 0.099 | <0.0001 |
| Roads | 869 | 1.24 | < 0.0001 | 532 | 0.96 | < 0.0001 | <0.0001 |
| **Total** | **1603** | **1.39/1.43††** | **< 0.0001** | **786** | **0.94/0.83††** | **< 0.0001** | **<0.0001** |

*) The p-value of Wilcoxon test with null hypothesis that the distribution is symmetrically centered around one.

**) The p-value of the test with null hypothesis that cost overrun is balanced by benefit overrun (Mann-Whitney test). See main text for explanation.

†) Bus rapid transit.

# A Philosophical Question: Newbold (2019)

When is no number better than some number?

- If our predictive models have high error rates, then *no number* can be better than *some number*.
- Regulator will choose level of pollution abatement where $\widehat{MB} = \widehat{MC}$.
  - Even with adequate explanation of uncertainty and unquantified benefits, will decision-makers know how to weigh economic efficiency considerations alongside other priorities?
- Can providing some number be better than no number if it helps us see whether quantifiable benefits still outweigh quantified costs?

# Efficiency ≠ Equity

An assessment of economic efficiency generally does not consider distributional impacts (i.e., equity).

- Equity is subjective
- There is no *positive* way to determine a "better" distribution of income or environmental protection.
- As such, BCAs typically treat an additional dollar of income as equivalent no matter who receives it.
  - *Is this approach positive?*

Source: Vox, "What Americans really think about billionaires during the pandemic"

# Part 4: Equity Weights

# Equity Weighting in BCA is Controversial

A short section on equity weights was included in the proposed revisions to circular A4:

***e. Weights and Benefit-Cost Analysis***

In traditional benefit-cost analysis, the sum of the net benefits across society equals the aggregate net benefits of the regulation. Any approach to estimating aggregate net benefits uses distributional weights. An analysis that sums dollar-denominated net benefits across all individuals to measure aggregate net benefits—as the traditional approach generally does—adopts weights such that a dollar is equal in value for each person, regardless of income (or other economic status).[111]

Agencies may choose to conduct a benefit-cost analysis that applies weights to the benefits and costs accruing to different groups in order to account for the diminishing marginal utility of goods when aggregating those benefits and costs. Diminishing marginal utility means that an additional unit of a good is more valuable to a person if they have less of it than if they have more of it. Weights of this type are most commonly applied in the context of variation in net benefits by income, consumption, or other measures of economic status. If you decide to produce an estimate of net benefits utilizing such weights, you may treat it as your primary estimate of net benefits, or as a supplemental estimate. The same weights should be applied to benefits and costs consistently in each analysis, and the weights that you used in each analysis should be communicated clearly. As noted in the section "*Some General Considerations*" you should also present traditionally-weighted estimates (sometimes, albeit inaccurately, referred to as "unweighted" estimates) when conducting an analysis using weights that account for diminishing marginal utility.

See the whole document.

# Equity Weighting in BCA is Controversial

The proposed revisions were reviewed by an expert panel and released in August, 2023. You can read their comments here. Four of the commenters responded to guidance on equity weights. Some of their considerations:

> and justifying a recommendation – could be moved to the preamble. A streamlined circular A-4 – clearly guiding agencies with what they *should do* in conducting their regulatory impact analyses – would be a more effective resource. The circular does not need to present a full array of perspectives – such as in the discussion of discount rates and equity weighting. If this information is deemed necessary, then it can be move to the preamble, and also made available on www.evaluation.gov or similar public resource. Some of this reads as an abstract guidance – and lengthy guidance – for hypothetical scenarios that would be rare for most agencies. For example, the discussion of equity weighting – with the exception of the final
>
> > Thus, on balance, **I strongly recommend that equity-weighting is permitted as an option for regulatory analysis using the methodology in the proposed guidance, but that due to the relatively early stage of the literature that implements the concept, the equity-weighted analysis should not be the primary analysis, but rather could be presented accompanying a more standard analysis**. I believe that it provides very useful information on the consequences of the regulation for social welfare and should be permitted as part of a careful regulatory analysis.

# Why Not Equity Weight?

A few reasons offered by the expert panel and also discussed in prior readings:

- Equity weighting analysis takes away from other important considerations.
  - Would agencies forgo EJ and distributional work if they have equity weights?
- It makes the BCA less transparent. The values are a black box.
  - It's easy to interpret a $ value, not so much an equity weighted value.
- VSL is already a progressive valuation metric. Weighting a weighted metric.
- Unclear society would actually prefer weighted outcomes.
  - What if most of the redistribution moves $ from middle class to lower class?
- Economists are still fleshing out the implications of different equity weighting approaches.

# An Example to Illustrate Equity Weights: PCE

Suppose a federal agency is regulating a chemical used in dry cleaning facilities.

Let's pull some plausible numbers from the economic analysis for PCE (2023).

- Costs $15 million
- Benefits $10 million

Image source: Tetrachloroethylene ("PCE") CDC fact page

# An Example to Illustrate Equity Weights: PCE

Traditional Kaldor-Hicks efficiency criterion:

$$Benefits - Costs > 0$$

In this case:

$$10m - 15m < 0 \rightarrow \text{~~Efficient.~~}$$

The efficiency criterion with equity weights $\omega_i$ is:

$$\omega_1 Benefits - \omega_2 Costs > 0$$

Image source: Tetrachloroethylene ("PCE") CDC fact page

# Quick Aside

The following equation is a basic example where all the benefits accrue to one group with weight $\omega_1$ and all the costs accrue to another group $\omega_2$:

$$\omega_1 Benefits - \omega_2 Costs > 0$$

For real-world applications, the efficiency criterion equation is more like:

$$\omega_i \sum_{i=1}^{N} Benefits - \omega_i \sum_{i=1}^{N} Costs > 0$$

Benefits and costs accrue to and are weighted across all groups $i \in N$.

# What are the Weights?

A common equity weight used in the UK for policy analysis:

$$\omega_i = \left(\frac{Y_{avg}}{Y_i}\right)^{\eta}$$

In the above equation:

- $\omega_i$ is the weight for group *i*.
- $Y_i$ represents the income of the same group.
- $\eta$ is the elasticity of marginal utility (recall Ramsey discounting).

# Equity Weights and the Elasticity of Marginal Utility

A common equity weight used in the UK for policy analysis:

$$\omega_i = \left(\frac{Y_{avg}}{Y_i}\right)^{\eta}$$

A few characteristics of $\eta$, the elasticity of marginal utility of consumption.

- Intuition: how quickly does marginal utility decline in consumption?
- In the Ramsey case, $\uparrow \eta$ implied greater intergenerational inequality aversion.
- In this case, $\uparrow \eta$ implies greater aversion to income inequality.

# Equity Weights with Varying Elasticity of Marginal Utility

Let's look at the implications of different $\eta$. Economists assume $\eta \in [0, 2]$. And research has suggested $\eta$ is realistically 1.2 – 1.6 (Acland and Greenberg, 2023).

$$\omega_i = \left(\frac{Y_{avg}}{Y_i}\right)^{\eta}$$

| $\boldsymbol{\eta}$ | $\boldsymbol{\omega_i}$ | **Intuition** |
|---|---|---|
| $\eta$ = 0 | 1 | No equity weight. Current practice. |
| $\eta$ = 1 | $\left(\frac{Y_{avg}}{Y_i}\right)$ | Marginal utility of additional income is twice as high with half the income. |
| $\eta$ = 2 | $\left(\frac{Y_{avg}}{Y_i}\right)^2$ | Averse to income inequality. MU is 4X as high with half the income. |

# Let's Go Back to the PCE Example

Suppose income of the workers is $30,000 and that all costs will be passed on to consumers of dry-cleaning businesses with incomes of $90,000. Average income in society is $60,000.

- Weight for the dry-cleaners $\omega_1 = \left(\frac{Y_{avg}}{Y_1}\right)^{\eta} = \left(\frac{60}{30}\right)^{1} = 2$
- Weight for the consumers $\omega_2 = \left(\frac{Y_{avg}}{Y_i}\right)^{\eta} = \left(\frac{60}{90}\right)^{1} = 2/3$
- Efficiency Test:

$$\omega_1 Benefits - \omega_2 Costs > 0$$

2($10m) – 2/3($15m) = $10m >0

# An Efficiency Test of PCE with Different Equity Weights

| $\eta$ | $\omega_i$ | Intuition | BC Test |
|---|---|---|---|
| $\eta$ = 0 | 1 | No equity weight | 10-15 = -5 |
| $\eta$ = 1 | $\left(\frac{Y_{avg}}{Y_i}\right)$ | Marginal utility of additional income is twice as high with half the income. | 20 – 10 = 10 |
| $\eta$ = 2 | $\left(\frac{Y_{avg}}{Y_i}\right)^2$ | Averse to income inequality. MU is 4X as high with half the income. | 4(10)-(4/9)20 = 40-8.8 =32 |

# Benefit Cost Analysis: Take-Aways

Some take-aways:

- Benefit cost analysis provides useful information to policymakers and society.
- Environmental BCAs may systematically undercount true benefits.
  - Uncertain benefits, use of WTP vs WTA, limited quantification of non-use values.
- BCA has limitations and should be wielded carefully. BCA must be transparent about uncertainty and list unquantified benefits.
- BCA is only one part of regulatory analysis.
  - Limitations of BCA can be overcome with additional analysis of equity, distributional impacts, small business analysis, etc.

# Reminders

On Wednesday we will pick up with Environmental Justice History.

Readings for Wednesday, October 4th:

1. Banzhaf et al. (2019)
2. (optional) Qiang et al (2021)