(An Introduction to) Benefit-Cost Analysis

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Some objectives of the class

- Present the general principles of benefit-cost analysis (BCA)
- Discuss the policy use of BCA
- Present some advantages of BCA, but also indicate some conceptual and practical limits
- Discuss some « advanced » issues in BCA (e.g. nonmarket valuation, equity, happiness research)
Some remarks about the class

- BCA literature is huge. Only a selection of topics, which depends on my own interests, and on the topic of the class (i.e. risk)

- Please ask questions! Discussions welcome

- Some methodological aspects of BCA are subject to criticisms and current improvements, and are thus largely open to discussion

- Thanks to some of my coauthors Christian Gollier, James Hammitt and Henrik Andersson for sharing some slides
Some useful references

- Pearce, Atkinson and Mourato, 2006, “CBA and the Environment, Recent Developments”, OECD. [broad, precise, up to date, and accessible with technical annexes]
- Boardman et al., 2006, “CBA: Concepts and practices”, Pearson. [broad, good basic economics]
- Adler and Posner, 2001, “CBA, Legal, Economic and Philosophical Perspectives”, Chicago UP. [collected papers by top social scientists, critical toward BCA]
- Fuguitt and Wilcox, 1999, “CBA for Public Sector Decision Makers”, Quorum Books. [economic, nontechnical]
- Treich, 2005, “L’ACB de la Prévention des Risques”, see author’s webpage. [in french, for some references]
1. Introduction to BCA
   includes a discussion about the policy use of BCA

2. WTP and Economic Value
   how to estimate benefits and costs?

3. Standard Difficulties in BCA
   how to treat equity, longterm, uncertainty, and bounded rationality?

4. Concluding discussion: Happiness research
   a « third way » for nonmarket valuation?
Chapter 1. Introduction to BCA

- Basic principles of BCA
- BCA in policy-making
- BCA vs. other decision-making procedures
The (possible) stages of BCA

1. Define what is the problem (i.e., what will happen without policy intervention)
2. Identify scenarios
3. Define the perimeter of the analysis
4. List the consequences of each scenario
5. Quantify the consequences
6. Monetize consequences
7. Aggregate and discount monetized costs and benefits
8. Analyze the sensitivity of the results to the parameters’ assumptions
9. Examine the distribution of the costs and benefits
10. Derive policy recommendations
11. Discuss assumptions and results with stakeholders
12. Validate scientifically (by peer reviewing)
13. Make the analysis easily accessible to the public
Two distinct questions

- Question 1: What is the “socially efficient” policy?

- Question 2: How to organize the system?

That is, how to give incentives (e.g. taxes, permits, liabilities, norms...) to the agents (e.g. consumers, firms, NGO, experts, policy-makers...) to lead them to make decisions consistent with the socially efficient policy?

- BCA mostly focuses on question 1, the normative question

[Remark: “social”, “socially” refers to the people living in the society]
A « Socially Efficient » Policy

- This is the policy that **maximizes the net social benefit**

- Difficulty 1: Costs and benefits are of different nature

  To make them comparable, need to convert costs and benefits into the same unit (usually money) – use (competitive) supply and demand prices (if any) for good or services, and more generally the willingness-to-pay (WTP) and WTA concepts

- Difficulty 2: Costs and benefits accrue to different economic agents

  Basic postulates of BCA (Harberger and Jenkins, 2002): « to obtain a measure of net benefit or cost for an aggregate of individuals or for society as a whole, one simply adds up (across all individuals in the relevant group) the costs and benefits »
Willingness to pay (WTP)

- Fundamental concept in BCA
- WTP = a « monetary-equivalent » of the change in citizens’ welfare due to a policy change
No weights – Equity?

- One adds WTPs across citizens without weights
  - A rich’s WTP of 100 euros = a poor’s WTP of 100 euros

- There may be winners and losers from the policy

- General justification: separation between efficiency and redistribution issues
  - Some policy-makers must decide about (e.g.) the level of risk-reducing expenditures, and other policy-makers must choose the taxation scheme
Two methods to estimate WTPs

1. Revealed preferences (RP)

   Based on real decisions made by individuals. Markets.

   Example: Housing price and air pollution

2. Stated preferences (SP)

   Based on citizens’ survey

   More flexible, but several biases.
1- Revealed Preferences

- People assumed to prefer the choice they make to available alternatives
  - Attributes of alternatives are known
  - People are free to choose among them

- Choices are observed, but alternatives (and their costs) must be inferred

- Preferred (to SP) by many economists since:
  - Actual decisions – individuals have incentives to be well informed
  - Decisions repeated – individuals learn
Discrete consumer purchase

- Consumer decide on buying a single good attribute
- One good – one price
- Discrete choice

Examples:
- Smoke detectors
- Bicycle helmets
Hedonic prices (HP)

- Formalized by Sherwin Rosen (JPE, 1974)

- Often ascribed to Adam Smith (1776): “The wages of labour vary with the ease or hardship, the cleanliness or dirtiness, the honourableness or dishonourableness of the employment.”

- Have been used extensively on labor markets to value safety and on property markets to value environmental amenities
  - Property market
    - price, number of rooms, lot size, neighborhood, schools, air quality, etc.
  - Labor market
    - salary, responsibilities, health risks, etc.
Cost of illness (and Human capital)

- Expenditures made in response to morbidity, as well as loss in wage and profits

- Typical example is expenditures on medical services

- Problem if health expenditures are subsidized, or made by social administrators (reflect other considerations)

- Usually underestimate WTP
2- Stated preferences

- Individuals’ preferences elicited in a hypothetical setting – determine how individuals would choose/behave if decisions were real

- Flexible – design based on wants and needs of policy maker and/or analyst

- Approach controversial among many economists due to its hypothetical nature
Stated preference techniques

- Contingent valuation method (CVM)
- Stated choice modeling
- Standard gamble / Time trade off
- Risk-risk trade off
- …..

Some confusion about definitions:
- Transportation: “Stated preference” often used to define “stated choice modeling”
- Environment: “Contingent valuation” sometimes used to define all SP methods

See Bateman et al. (2002) and Champ et al. (2003) books for state of the art guidance in resp. the UK and the US
Carson et al. (1995) produced a bibliography of the CVM, identifying more than 4,000 entries in 40 countries.

Source: Carson and Hanemann (2005)
CVM and the NOAA Panel

- Although still controversial, the CVM has gained acceptance.

- Much of the impetus to this acceptance were the conclusions of the NOAA (National Oceanic and Atmospheric Administration) panel (Arrow et al., 1993) which was formed in response to criticism of the CVM. (The Exxon Valdez oil spill in Alaska in 1989.)

- Came up with recommendations on how to elicit monetary values based on survey methods.
BCA as a « Populist » Approach

- BCA computes costs and benefits **based on individual welfare**
- Yet, one does not directly observe individual welfare
- The main part of BCA consists in **obtaining monetary-equivalent changes of welfare (WTP) from observed individual decisions**
- This building block of BCA is critical: what if citizens/consumers make « inconsistent » decisions? Major difficulty
BCA and Market Failure

- BCA evaluates a policy, typically a government’s decision

- Thus postulates a market failure (public good, externality, monopoly, asymmetric information…) which justifies the government intervention in the first place

- BCA therefore defines, in a sense, the optimal level of government intervention

- Remark: In some cases (e.g. food safety norms, cigarette taxation, seatbelts …) the market failure justification for government intervention may not be open to discussion
BCA and the « Stakeholders’ Society »

- BCA takes a stakeholders’ viewpoint: the consequences for all stakeholders of a policy should, in principle, be evaluated.

- Typically, BCA helps evaluate the social consequences of firms decisions.

- May be useful to assess (e.g.) the economic value of corporate social responsibility (CSR).
BCA as an Aid to Policy-Making

- May help policy-makers to make better decisions, and organize the communication around these decisions
- May help organize discussions among stakeholders
- May leave open the possibility to an external person to challenge the hypotheses, and thus the results of a BCA
- May help decision-makers define priorities among a set of policies
### Copenhagen Consensus

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<td>1 Diseases</td>
<td>Control of HIV/AIDS</td>
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<td>2 Malnutrition</td>
<td>Providing micro nutrients</td>
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<td>3 Subsidies and Trade</td>
<td>Trade liberalisation</td>
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<td></td>
<td>4 Diseases</td>
<td>Control of malaria</td>
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<td><strong>Good</strong></td>
<td>5 Malnutrition</td>
<td>Development of new agricultural technologies</td>
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<td>6 Sanitation &amp; Water</td>
<td>Small-scale water technology for livelihoods</td>
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<td>7 Sanitation &amp; Water</td>
<td>Community-managed water supply and sanitation</td>
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<td>8 Sanitation &amp; Water</td>
<td>Research on water productivity in food production</td>
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<td>9 Government</td>
<td>Lowering the cost of starting a new business</td>
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<td><strong>Fair</strong></td>
<td>10 Migration</td>
<td>Lowering barriers to migration for skilled workers</td>
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<td></td>
<td>11 Malnutrition</td>
<td>Improving infant and child nutrition</td>
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<td></td>
<td>12 Malnutrition</td>
<td>Reducing the prevalence of low birth weight</td>
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<td></td>
<td>13 Diseases</td>
<td>Scaled-up basic health services</td>
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<tr>
<td><strong>Bad</strong></td>
<td>14 Migration</td>
<td>Guest worker programmes for the unskilled</td>
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<td>15 Climate</td>
<td>Optimal carbon tax</td>
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<tr>
<td></td>
<td>16 Climate</td>
<td>The Kyoto Protocol</td>
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<tr>
<td></td>
<td>17 Climate</td>
<td>Value-at-risk carbon tax</td>
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A panel of economic experts, comprising eight of the world’s most distinguished economists, was invited to consider these issues. The members were Jagdish Bhagwati of Columbia University, Robert Fogel of the University of Chicago (Nobel laureate), Bruno Frey of the University of Zurich, Justin Yifu Lin of Peking University, Douglass North of Washington University in St Louis (Nobel laureate), Thomas Schelling of the University of Maryland, Vernon Smith of George Mason University (Nobel laureate), and Nancy Stokey of the University of Chicago.
Is there a «statistical murder»?

Median cost/life year saved
US $1000 1983

Health care
Consumer product safety
Highway safety
Occupational safety
Environment

19
23
78
88
7600

Source: Tengs and Graham (1996) and Lomborg (2001)
Brief history of BCA – Some concepts

- Jules Dupuit, a french engineer in 19th century, introduced the WTP concept

- Marshall (1890) and Pigou (1920) seminal contributions on externalities, then Samuelson (1954) on public goods

- Hicks (1939) and Kaldor (1939) on potential Pareto improvements, and Scitovsky (1941) on hypothetical compensation

- Lipsey and Lancaster (1956-57) on the theory of second-best

- Drèze (1962) and Shelling (1968) on the value of life, Arrow and Lind (1970) on uncertainty

- Marglin (1963) and Sandmo and Drèze (1971) on social discount rates

- Weisbrod (1964), Arrow and Fisher (1974) and Henry (1974) on (quasi-) option values
Brief history of BCA – Applications

- Army Corps of Engineers – Flood Control Act, in the 30s

- Methodological « Green book » by the Rand Corporation (1950), and the Budget Circular A-47 (1952)

- Large worldwide development in 60s and early 70s: World Bank projects, manuals OECD and UNIDO or infrastructures projects in the UK and in France; Little and Mirlees (1974) on BCA in developing countries

- Slow down in the late 70s, unclear reasons - Adler et Posner (2001) : "it would be useful to have an explanation for the political fortunes of BCA - why it was relatively popular before and after the 70s but it was unpopular during that decade"

- Major development in the US from early 80s – Major piece of legislation was (1981) Executive Order (EO) 12291

- EU – art. 174 of the treaty states that costs and benefits of action and inaction should be compared – since 2001, the Commission requires impact assessments

- International organisations : (IPCC, 1995, 2001), Working group 3 on socio-economic dimensions ; See also, e.g., « WHO guidelines »
Stern Review (2007)

- BCA of abating greenhouse gases emissions
- Large mediatic impact
- « Integrated assesment » approach, i.e., a climate-economy model
- Different conclusions compared to previous climate-economy models (e.g., to DICE model of Nordhaus, 1994)
- Stern review: Costs of climate change equivalent to 5% of world GDP, 4.45 trillions euros – by efficient environmental and energy policies this cost could be reduced to 0.1% of GDP
- Controversy about the low discount rate used
Current policy context

- BCA is much less used in Europe than in the US

- However, traditionally more used in some sectors (e.g. transport), and for some risks (e.g. flood)

- BCA not uniformly used across Europe (seems to be more used in the UK and nordic countries than in southern Europe)
Precautionary Principle (PP)

- European Commission, “Communication on the Precautionary Principle” (February 2000): measures based on the PP should be:
  - proportional to the chosen level of protection,
  - non-discriminatory in their application,
  - consistent with similar measures already taken,
  - based on an examination of the potential benefits and costs of action or lack of action (including, where appropriate and feasible, an economic cost/benefit analysis),
  - subject to review, in the light of new scientific data, and
  - capable of assigning responsibility for producing the scientific evidence necessary for a more comprehensive risk assessment.
Variation in Better Regulation measures across EU member states

<table>
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<tr>
<th>Country</th>
<th>Better regulation programme</th>
<th>Specific RIA policy</th>
<th>Obligatory RIA policy</th>
<th>Alternative instruments considered</th>
<th>Guidelines on RIA</th>
<th>Coordinating body for RIA</th>
<th>Consultation part of RIA</th>
<th>Formal consultation procedures</th>
<th>Direct stakeholder consultation</th>
<th>Tests of impact on small enterprises</th>
<th>Exemptions for SMEs</th>
<th>Total Y+(Y)</th>
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Total Y+(Y): 19 13 12 15 15 14 12 12 11 7 5

Legend

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</table>

The legal context in France

Several French public reports have stressed the need to develop socio-economic evaluation


New legal obligation to develop impact assessment studies in France (Loi organique n° 2009-403 du 15 avril 2009 relative à l’application des articles 34-1, 39 et 44 de la Constitution)

“Le Gouvernement a l’obligation de transmettre au Conseil d’Etat puis au Parlement, à l’appui de chaque projet de loi, une étude d’impact”
The European context

- Article 130r of the Treaty on European Union (1992) requires that: « in preparing its policy on the environment, the Community shall take account of (…) the potential benefits and costs of action and lack of action » - See also the Nice Treaty (2001) art. 174(3)

- European communication on the Precautionary Principle (PP) (see Wiener, 2006, for an extensive discussion on the European approach to the PP vs. BCA in the US)

- Proportionality principle – general law principle of the European Commission

_Pfizer Animal Health S.A. v. Council, Case T-13/99, 2002 WL 31337 (European Court of First Instance, Sept. 11, 2002), 410-411: « The Court considers that a cost/benefit analysis is a particular expression of the principle of proportionality in cases involving risk management »

- « Better Regulation » Initiative»; Impact Assessment (IA) studies. Of the 70 Extended IAs in 2003-05, fewer than 40% quantify and monetize either Bs and Cs; only 17% compared net benefits (Renda 2006, p.63). “IA: Next steps” (2004) includes “improved quantification and a possible further monetisation of impacts”
Monetization in EU impact assessments

Costs

Benefits

Figure 2  Percentage of impact assessments that report cost information.
Notes: For 2003–2007, the number of observations summarized is 15, 21, 29, 21, and 25, respectively.

Figure 3  Percentage of impact assessments that report benefit information.
Notes: For 2003–2007, the number of observations summarized is 15, 21, 29, 21, and 25, respectively.

Source: Cecot et al. (2008)
Some guidelines

- OECD (1997) guidelines on regulatory impact analysis (RIA) – OECD states that BCA is the « most desirable » form of RIA analysis, but notes that it is not used in many countries because of the difficulty of placing money values on regulatory benefits.

- US EPA has extensive guidelines for preparing economic analyses of regulation (US EPA 2000).


- See also, e.g., the Canadian Government (1995) and UK Cabinet Office, « green book » guidelines.
Legal framework in the US

- Every President since the 70s has required some form of regulatory impact assessment. President Carter issued EO 12044 requiring economic analysis.

- EO 12291 in 1981 requires that for any new regulation « the potential benefits outweigh the costs ».

- Superseded by EO 12866 in 1993, replaced by « benefits justify costs ». Benefits include « economic, environmental, public health and safety, other advantages, distributive impacts and equity ».

- In effect, no formal requirement that benefits actually exceed costs in a quantitative sense.

- US EPA is the major regulatory agency involved in BCA. A BCA is required by OMB only for major regulations (> $100 million).

- In 2003, the US OMB issued new guidance that requires agencies to supplement BCA with cost-effectiveness studies.
Table 1-1: Estimates of the Total Annual Benefits and Costs of Major Federal Rules, October 1, 1995 to September 30, 2005 (millions of 2001 dollars)

<table>
<thead>
<tr>
<th>Agency</th>
<th>Number of Rules</th>
<th>Benefits</th>
<th>Costs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Department of Agriculture</td>
<td>7</td>
<td>3,530-6,747</td>
<td>2,215-2,346</td>
</tr>
<tr>
<td>Department of Education</td>
<td>1</td>
<td>633-786</td>
<td>349-589</td>
</tr>
<tr>
<td>Department of Energy</td>
<td>6</td>
<td>5,194-5,260</td>
<td>2,958</td>
</tr>
<tr>
<td>Department of Health and Human Services</td>
<td>19</td>
<td>21,313-33,268</td>
<td>3,853-4,029</td>
</tr>
<tr>
<td>Department of Homeland Security (Coast Guard)</td>
<td>1</td>
<td>44</td>
<td>305</td>
</tr>
<tr>
<td>Department of Housing and Urban Development</td>
<td>1</td>
<td>190</td>
<td>150</td>
</tr>
<tr>
<td>Department of Justice</td>
<td>1</td>
<td>275</td>
<td>108-118</td>
</tr>
<tr>
<td>Department of Labor</td>
<td>4</td>
<td>1,138-3,440</td>
<td>349</td>
</tr>
<tr>
<td>Department of Transportation</td>
<td>13</td>
<td>2,913-4,948</td>
<td>3,212-6,622</td>
</tr>
<tr>
<td>Environmental Protection Agency</td>
<td>42</td>
<td>58,670-394,454</td>
<td>23,572-26,200</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>95</strong></td>
<td><strong>93,899-449,412</strong></td>
<td><strong>37,071-43,665</strong></td>
</tr>
</tbody>
</table>

Table 1-2 provides additional information on aggregate benefits and costs for specific agency programs. In order for a program to be included in Table 1-2, the program needed to have finalized three or more rules in the last 10 years with monetized costs and benefits.
US EPA rules and mortality risks

- « EPA rules continue to be responsible for the majority of costs and benefits generated by federal regulation » (OMB, 2006)

- Principally air-quality rules (about 80% of EPA rules)

- Clean Air Act: mortality risks reduction represent about 90% of benefits; Mortality-related policy effects have therefore dominated BCA

- Estimated benefits of avoided skin-cancer mortality accounted for 99% of quantified benefits of Montreal Protocol (EPA Regulatory Impact Assessment)

- Worldwide mortality damages may account for more than half climatic damages (IPCC, 1995, p. 198)

- How to obtain monetary-equivalent benefits from mortality risk reductions? => Value of a Statistical Life (VSL)
Regulatory reference values for the VSL

- US EPA uses VSL values between $1 and $10 million, with a mean estimate of $6.2 million (2000 prices)

- FDA uses a slightly lower value $5.5 million and US DoT uses $3.3 million and US FAA $3 million (2002 prices) (Viscusi and Aldy, 2003; Robinson, 2007)

- « Official values » in transport (in 2005 prices): New Zealand ($1.79 million), Norway ($2.051 million), Sweden ($1,996 million), UK (2,308 million)

- European Union DG Environment (2001) recommends using a VSL of €1 million and €2.5 million for a high value (€2.5 in 2001 prices leads to €3.42 in 2009 prices); similar values in ExternE and SEA guidance
Comparing EU IA and US BCA

- US requires BCA for major regulations only ($>100m)
- EU requires IA for a wide variety of policy initiatives
- Quality in terms of economic information of EU IA usually low and much lower than US BCA (Renda, 2006)
- Yet, EU IAs has included more economic information over time, and the « quality increases with expected cost of the proposal » (proportionate analysis) => quality of EU IA similar to that of US BCA for policies $>100m (Cecot and al, 2008)
Comparing BCA with other criteria

- BCA can be viewed as the ultimate policy evaluation tool
- But BCA requires a lot of information
- And rests on strong assumptions (welfarism, separation between efficiency and equity…)
- In practice, hybrid evaluation tools are often used (e.g. in health policy and medical decision-making)
Cost-effectiveness analysis (CEA)

- CEA either minimizes the cost for a given « effectiveness objective », or maximizes the « effectiveness objective » for a given cost budget

- Common policy criterion

- Examples of effectiveness objectives: lives-saved or life-per-year-saved, Qalys (in medical decision-making), CO2 concentration target..

- One advantage: avoid money unit conversion ; also, sometimes only the costs of a policy are known, not the benefits (see the recently published baseline study of REACH)

- Main problem: what should be the effectiveness objective? Need somehow to be compared to cost => back to BCA

- Same problem with multi-criteria analysis (which involve multiple « effectiveness objectives »)
A Gallery of other criteria

- Internal Rate of Return
- Strategic Environmental Assessment
- Life Cycle Analysis
- Comparative Risk Assessment
- Risk-Benefit Analysis
- Risk-Risk Analysis
- Health-Health Analysis

See, e.g., Pearce et al. (2005) for discussions and references
BCA vs. other criteria

- BCA may be seen as the most comprehensive approach but the various “procedures are not substitute to each other” (Pearce et al., 2006)

- Statement of economists (Arrow et al., Science, 1996) “We suggest that BCA has a potentially important role to play in helping inform regulatory decision-making, although it should not be the sole basis for such decision-making”.

- Panel on CEA in Health and Medecine “CEA is an aid to decision making, not a complete procedure for making resource allocation decisions in health and medicine, because it cannot incorporate all the values relevant to such decisions”.

45
Chapter 2. WTP and Economic Value

- WTP and WTA
- The VSL – theory and practice
- Valuing health improvements
- Estimating costs
A gain in an individual’s utility (or well-being, or welfare) from a policy change can be measured by the maximum amount of good and services – or money income (wealth) – that he or she would be willing to give up in order to obtain the policy change.

This amount is the WTP.
Theory: WTP and Utility

- Consider an individual with utility $U(w,z)$ in which $w$ is wealth and $z$ is a public good (health, environment) provided by the government.

- Let consider a policy that changes the level of public good provided from $z$ to $z'$.

- Assume $U(w,z') > U(w,z)$: the change is beneficial.

- Then WTP is defined by $U(w - \text{WTP}, z') = U(w, z)$.

- The WTP is the individual’s *compensating variation*, and it is measured relative to an initial level of utility.
Willingness to Accept (WTA)

- The WTA is defined by $U(w,z')=U(w+WTA,z)$

- The WTA is the individual’s *equivalent variation*, and it is measured relative to level of utility after the change.

- Remark: there exist two other measures when the policy change *decreases* utility. Compensating variation is then measured by WTA, and equivalent variation is then measured by WTP.
WTP vs. WTA

- Until a few decades ago, economists assumed the difference between WTP and WTA was modest

  « (...) a receipt forgone of a given amount is the equivalent of a payment of the same amount » (Coase, 1960, p. 7)

- That is, for BCA purposes it did not matter whether WTP or WTA was used

- There are theoretical reasons for supposing that WTA and WTP should be similar

- But empirical estimates have shown that WTP and WTA differ significantly in practice
## WTA/WTP Ratios

<table>
<thead>
<tr>
<th>Type of good</th>
<th>Ratio</th>
<th>Standard error</th>
</tr>
</thead>
<tbody>
<tr>
<td>Public or non-market</td>
<td>10.4</td>
<td>2.5</td>
</tr>
<tr>
<td>Health and safety</td>
<td>10.1</td>
<td>2.3</td>
</tr>
<tr>
<td>Private goods</td>
<td>2.9</td>
<td>0.3</td>
</tr>
<tr>
<td>Lotteries</td>
<td>2.1</td>
<td>0.2</td>
</tr>
<tr>
<td>Timing</td>
<td>1.9</td>
<td>0.2</td>
</tr>
<tr>
<td>All goods</td>
<td>7.2</td>
<td>0.9</td>
</tr>
</tbody>
</table>

Source: Horowitz and McConnell (2002, JEEM) based on 45 usable studies
Debate about robustness

- There is a lot of experimental evidence for WTP/WTA discrepancy

- But does WTP/WTA discrepancy disappear with...

  .. repetition and learning?


  .. market?

Implication for BCA?

- Many economists tend to prefer using WTP
  
  “The WTP format should be used instead of compensation required because the former is the conservative estimate” (Arrow et al., 1993, p. 51)

- But why there should be a conservatism bias is not clear

- Goes back to the fundamental debate about whether “irrationalities” (like the “endowment effect”, “loss aversion” or the “status quo bias”, typically invoked by psychologists to explain WTP/WTA disparities) should be accounted in BCA
An (Hypothetical!) Example

- Assume you are forced to play Russian Roulette using a revolver with 10,000 chambers, 5 of which are loaded.

- You are offered the opportunity to buy the removal of one bullet from the revolver before playing. What is the most you would pay to remove one bullet (from 5 to 4)? = WTP

- What is the minimum you would need to receive to accept to add one more bullet (from 5 to 6)? = WTA
WTP/WTA for Changes in Risk

Indifference curve

Wealth

0  Survival probability (\(= 1 - \text{risk}\))  1
WTP/WTA for Changes in Risk

Indifference curve

Wealth

0 Survival probability ( = 1 - risk) 1

WTP

Δp
WTP/WTA for Changes in Risk

Wealth

Survival probability ( = 1 - risk)

Indifference curve

$\Delta p$

WTP

WTA

$\Delta p$
A simple model

Let define a (state-dependent) expected utility as \( U(w,z) = (1-p+z)u(w) + (p-z)v(w) \)

In which \( u(w) \) is the utility of wealth if alive, and \( v(w) \) is the utility of wealth if dead (bequest), with \( u > v \) and \( u' > v' \geq 0 \)

In the Russian Roulette example: \( p = 5/10,000 \) (baseline risk) with \( z = 0 \) and \( z' = 1/10,000 \)
Value of a Statistical Life (VSL)

- N (= 10,000) identical citizens in a community
- Each willing to pay $500 to prevent a 1 in 10,000 risk of death
- Value of a statistical life is $5 million in this community

\[
VSL = \frac{WTP}{\Delta p} = \frac{N \cdot WTP}{N \cdot \Delta p} = \frac{\text{Total}_WTP}{E(\text{lives}_\text{saved})}
\]
Let $V=(1-p)u(w) + pv(w)$

VSL: marginal rate of substitution between money and risk

$$VSL = \frac{d\,w}{dp} = \frac{u(w) - v(w)}{(1 - p)u'(w) + pv'(w)}$$
The VSL

- Does not measure what an individual is willing to pay to avoid his/her own death with certainty

- It measures the WTP (resp. The WTA) for an infinitesimal mortality risk reduction (resp. increase)

VSL:

1. Increases with baseline risk \( p \) ("dead-anyway effect", Pratt and Zeckhauzer, 1997, JPE)
2. Increases with wealth \( w \) (the sum of two effects)
VSL: A calibration exercise

- Let $y=16,500$ euros (French yearly income, INSEE 2004)
- Let $p=3/1,000$ (average yearly death probability for people aged 25-40)
- Let a life expectancy of 45, neglecting change in income and interest rate, $w=16,500 \times 45 = 742,500$
- Assume $v=0$, no bequest
- Assume relative risk aversion equals 0.5

$$VSL = \frac{742,500}{0.997 \times 0.5} \#1.5 \text{ millions euros}$$
## Wage differential studies

<table>
<thead>
<tr>
<th>Author(s)</th>
<th>Year</th>
<th>Implicit VSL US $ Million (2000 prices)</th>
<th>Country</th>
</tr>
</thead>
<tbody>
<tr>
<td>Thaler-Rosen</td>
<td>1975</td>
<td>$1.7-$1.9</td>
<td>US</td>
</tr>
<tr>
<td>Viscusi</td>
<td>1978-79</td>
<td>$5.5-$15.2</td>
<td>US</td>
</tr>
<tr>
<td>Dillingham</td>
<td>1977</td>
<td>$3.2-$6.8</td>
<td>US</td>
</tr>
<tr>
<td>Marin et al.</td>
<td>1982</td>
<td>$4.2</td>
<td>UK</td>
</tr>
<tr>
<td>Moore-Viscusi</td>
<td>1988</td>
<td>$3.2-$6.8</td>
<td>US</td>
</tr>
<tr>
<td>Berger-Gabriel</td>
<td>1991</td>
<td>$8.6-$10.9</td>
<td>US</td>
</tr>
<tr>
<td>Gegax et al.</td>
<td>1991</td>
<td>$2.7</td>
<td>US</td>
</tr>
<tr>
<td>Cousineau et al.</td>
<td>1992</td>
<td>$2.2-$6.8</td>
<td>Canada</td>
</tr>
<tr>
<td>Leigh</td>
<td>1995</td>
<td>$8.1-$16.8</td>
<td>US</td>
</tr>
<tr>
<td>Baranzini et al.</td>
<td>2001</td>
<td>$6.3-$8.6</td>
<td>Switz.</td>
</tr>
<tr>
<td>Kim</td>
<td>1993</td>
<td>$0.8</td>
<td>India</td>
</tr>
<tr>
<td>Liu et al.</td>
<td>1997</td>
<td>$0.2-$0.9</td>
<td>Taiwan</td>
</tr>
</tbody>
</table>

Source: Viscusi (2000), Viscusi and Aldy (2003, reports 30 VSL studies)
## Road safety studies

Table 1: Empirical estimates of the value of a statistical life in road traffic, in US$ 2005 (×1000)\(^a\)

<table>
<thead>
<tr>
<th>Authors</th>
<th>Country</th>
<th>Year of data, Study type</th>
<th>No. of estimates (^b)</th>
<th>Single</th>
<th>Lowest</th>
<th>Highest</th>
</tr>
</thead>
<tbody>
<tr>
<td>Andersson (2005a)</td>
<td>Sweden</td>
<td>1998, RP</td>
<td>1</td>
<td>1,425</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Atkinson and Halvorsen (1990)</td>
<td>US</td>
<td>1986, RP</td>
<td>1</td>
<td>5,521</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Beattie et al. (1998)</td>
<td>UK</td>
<td>1996, SP</td>
<td>4</td>
<td></td>
<td>1,510</td>
<td>17,060</td>
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<tr>
<td>Bhattacharya et al. (2007)</td>
<td>India</td>
<td>2005, SP</td>
<td>1</td>
<td>150</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Blomquist (1979)</td>
<td>US</td>
<td>1972, RP</td>
<td>1</td>
<td>1,832</td>
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<tr>
<td>Blomquist et al. (1996)</td>
<td>US</td>
<td>1991, RP</td>
<td>4</td>
<td>1,434</td>
<td>7,170</td>
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<tr>
<td>Carthy et al. (1999)</td>
<td>UK</td>
<td>1997, SP</td>
<td>4</td>
<td>4,528</td>
<td>5,893</td>
<td></td>
</tr>
<tr>
<td>Corso et al. (2001)</td>
<td>US</td>
<td>1999, SP</td>
<td>2</td>
<td>3,517</td>
<td>4,690</td>
<td></td>
</tr>
<tr>
<td>Ghosh et al. (1975)</td>
<td>UK</td>
<td>1973, RP</td>
<td>1</td>
<td>1,901</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hojman et al. (2005)</td>
<td>Chile</td>
<td>2005(^c), SP</td>
<td>1</td>
<td>541</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Holtkrantz et al. (2006)</td>
<td>Sweden</td>
<td>2004, SP</td>
<td>2</td>
<td>2,192</td>
<td>5,781</td>
<td></td>
</tr>
<tr>
<td>Jara-Diaz et al. (2000)</td>
<td>Chile</td>
<td>1999, SP</td>
<td>1</td>
<td>4,555</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Jenkins et al. (2001)</td>
<td>US</td>
<td>1997, RP</td>
<td>9</td>
<td>1,350</td>
<td>4,867</td>
<td></td>
</tr>
<tr>
<td>Johannesson et al. (1996)</td>
<td>Sweden</td>
<td>1995, SP</td>
<td>4</td>
<td>5,798</td>
<td>6,981</td>
<td></td>
</tr>
<tr>
<td>Jones-Lee et al. (1985)</td>
<td>UK</td>
<td>1982, SP</td>
<td>1</td>
<td>4,981</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lanoie et al. (1995)</td>
<td>Canada</td>
<td>1986, SP</td>
<td>2</td>
<td>1,989</td>
<td>3,558</td>
<td></td>
</tr>
<tr>
<td>Maier et al. (1989)</td>
<td>Australia</td>
<td>1989(^c), SP</td>
<td>6</td>
<td>1,853</td>
<td>5,114</td>
<td></td>
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<tr>
<td>McDaniels (1992)</td>
<td>US</td>
<td>1986, SP</td>
<td>3</td>
<td>10,131</td>
<td>36,418</td>
<td></td>
</tr>
<tr>
<td>Melinck (1974)</td>
<td>UK</td>
<td>1974(^c), RP</td>
<td>1</td>
<td>881</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rizzi and Ortuzar (2003)</td>
<td>Chile</td>
<td>2000, SP</td>
<td>1</td>
<td>486</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Schwab Christe (1995)</td>
<td>Switzerland</td>
<td>1993, SP</td>
<td>1</td>
<td>1,094</td>
<td></td>
<td></td>
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<tr>
<td>Vassanadumrongdee and Matsuoka (2005)</td>
<td>Thailand</td>
<td>2003, SP</td>
<td>2</td>
<td>3,208</td>
<td>5,458</td>
<td></td>
</tr>
<tr>
<td>Viscusi et al. (1990)</td>
<td>US</td>
<td>1991(^c), SP</td>
<td>1</td>
<td>11,091</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

VSL estimates in US$ 2005. Values transformed using purchasing power parities (PPP) and consumer price indices (CPI) from http://stats.oecd.org, 09/02/07. (For Chile and Thailand PPP and CPI from http://www.imf.org/external/data.htm were used.)

\(^a\): Many of the VSL estimates from de Blaey et al. (2003).

\(^b\): Several estimates were reported. When available, “preferred” values have been used.

\(^c\): Refers to year of study rather than data, since the latter is not available.

Source: Andersson and Treich (2007)
### Some US Public Programs

<table>
<thead>
<tr>
<th>Programs (Agency)</th>
<th>Estimated cost per avoided death – US $ Million ($1990)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Underground construction (OSHA)</td>
<td>0.1</td>
</tr>
<tr>
<td>Trihalomethane drinking water standards (EPA)</td>
<td>0.2</td>
</tr>
<tr>
<td>Crane suspended personnel platform (OSHA)</td>
<td>0.7</td>
</tr>
<tr>
<td>Children’s sleepwear flammability ban (CPSC)</td>
<td>0.8</td>
</tr>
<tr>
<td>Low altitude windshear equipment (FAA)</td>
<td>1.3</td>
</tr>
<tr>
<td>Hazard communication (OSHA)</td>
<td>1.6</td>
</tr>
<tr>
<td>Arsenic/copper smelter (EPA)</td>
<td>2.7</td>
</tr>
<tr>
<td>Grain dust explosion prevention standards (OSHA-S)</td>
<td>2.8</td>
</tr>
<tr>
<td>Radionuclides/uranium mines (EPA)</td>
<td>3.4</td>
</tr>
<tr>
<td>Ethylene dibromide drinking water standard (EPA)</td>
<td>5.7</td>
</tr>
<tr>
<td>Asbestos occupational exposure limit (OSHA-S)</td>
<td>8.3</td>
</tr>
<tr>
<td>Ethylene oxide (OSHA)</td>
<td>20.5</td>
</tr>
<tr>
<td>Uranium mill tailings (EPA)</td>
<td>31.7</td>
</tr>
<tr>
<td>Asbestos ban (EPA)</td>
<td>110.7</td>
</tr>
<tr>
<td>Diethylstilbestrol cattlefeed ban (FDA)</td>
<td>124.8</td>
</tr>
<tr>
<td>Hazardous waste land disposal ban (EPA)</td>
<td>4,190.4</td>
</tr>
</tbody>
</table>

Source: Viscusi (1998), Sunstein (2001)
Effect of wealth and baseline risk

- Empirical evidence that VSL increases with wealth is quite strong (Liu et al., 1997; Miller, 2000; Mrozek and Taylor, 2002; Viscusi and Aldy, 2003)

- Income-elasticity of VSL positive and usually < 1 (Viscusi and Aldy, 2003; Hammitt et al., 2006), but sometimes higher than 1 (Costa and Kahn, 2004)

Effect of age

- Ambiguous theoretical predictions - using a life-cycle models, VSL should track the life pattern of consumption (Johansson, 2002)

- Empirical evidence suggests that the relationship between VSL and age follows an inverted-U relationship, or is independent of age (Alberini et al., 2004; Viscusi and Aldy, 2007)
Risks type

- VSL usually higher for acute risks compared to latent risks, « in the range of 50-80% for a 20-year latency period » according to Pearce et al. (2005)

- There is a « cancer premium », estimated to be about one-third according to Hammitt and Liu (2003)

- VSL usually higher for uncontrollable risks and small risks (Carlsson et al., 2004)
Human capital

Traditionally, two conceptual approaches

- Human Capital
- WTP

Human Capital: Opportunity cost of early death, or say earning ability

- In practice: proportional to net income over lifetime

Problem: The human capital approach neglects risk preferences (e.g., risk aversion) and baseline risks, and therefore underestimates the social value of life savings
Health: Valuing morbidity, avoided injury

- The conceptual framework above could be used to estimate the value of reducing risks to health – Assume that \( v(w) \) is the utility of wealth if sick or injured (instead of dead)

- Most occupational studies have estimated a value of a statistical injury in the range of $20,000-$70,000 (Neegard, 1978; Biddle and Zarkin, 1988)

- Boiteux (2001), an influential report on transport in France, recommends to use a range from 2.2% of VSL and up to 15% of VSL for large injuries

- Health and Safety Executive in the UK recommends a value of €300,000 for large injuries
The QALY approach

- The Qualited-adjusted life-years (QALY) approach is used in medicine and public health policy (see e.g. Adler, 2006)

- Seems that there is little convergence about a single value for a QALY – range from $20,00 to $500,000 – NICE in the UK recommends £30,000 per QALY

- Institute of Medicine Panel Committee (2006): «Recommendation 1: Regulatory CEAs that integrate morbidity and mortality impacts in a single effectiveness measure should use the QALY to represent net health effects »

- The QALY is inconsistent with the WTP approach, unless strong assumptions are made about social welfare and individuals’ utilities underlying the WTP-approach (Hammitt, 2005, 2007)
Quality Adjusted Life Years

- “Health profile” = a time path through various “health states”

- Utility of a health profile = number of QALYs

- Utility of change in health profile = difference between utilities of the two profiles
Health profile

$q = \text{utility of health state}$

Time
## Cost per QALY in France

<table>
<thead>
<tr>
<th>Programme</th>
<th>Coût/QALY (en €)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Prévention du tabagisme par le généraliste</td>
<td>400</td>
</tr>
<tr>
<td>Stimulation cardiaque pour bloc auriculo-ventriculaire</td>
<td>1,700</td>
</tr>
<tr>
<td>Prothèse de hanche</td>
<td>1,800</td>
</tr>
<tr>
<td>Pontage coronarien pour angine de poitrine sévère</td>
<td>2,500</td>
</tr>
<tr>
<td>Greffe de rein</td>
<td>7,300</td>
</tr>
<tr>
<td>Dépistage mammographique cancer du sein (femme &gt; 50)</td>
<td>8,500</td>
</tr>
<tr>
<td>Transplantation cardiaque</td>
<td>12,200</td>
</tr>
<tr>
<td>Pontage coronarien pour angine de poitrine modérée</td>
<td>30,500</td>
</tr>
<tr>
<td>Dialyse en centre</td>
<td>33,300</td>
</tr>
<tr>
<td>Test de dépistage génomique viral des lots de sang</td>
<td>60,000</td>
</tr>
</tbody>
</table>
Estimating Costs

- Basically, the same approach as for benefits

- No difference in principle:
  - Cost (or reduction in benefits)
  - Reduction of costs (or benefits)

- Costs estimates: usually less controversial than benefits estimates, because less subject to “monetization” issues

- Many difficulties, but maybe more classical in economics. See, again, Kopp et al. (1997) and Pearce et al. (2006) for references
Example: Cost of CFC replacement

- Include:
  - Diverted resource to develop substitute products
  - Increased costs of producing substitutes
  - Loss of consumer surplus associated with higher retail prices
  - Ancillary quality changes or other attributes of substitute product

- Sometimes viewed as an accounting exercise. But how to pin down and quantify « all » major costs?

- When projects are not marginal, requires general equilibrium analysis.
A possible taxonomy of regulatory costs

A. Government Administration of Environmental Statutes and Regulation
   1) Monitoring
   2) Enforcement

B. Private Sector Compliance Costs
   1) Capital
   2) Operating

C. Other Direct Costs
   1) Legal and Other Transactional
   2) Shifted Management Focus
   3) Disrupted Production
   4) Redirected innovation

D. Nonmonetary Costs
   1) Environmental externalities
   2) Worker Health

E. General Equilibrium Effects
   1) Product Substitution
   2) Labor market effects
   2) Discouraged Investment

F. Transition Costs
   1) Unemployment
   2) Obsolete Capital

G. Social Impacts

Usually most part of the economic analysis
Private sector compliance costs

- **Capital costs**

  Include « one-time » expenditures on installation or retrofit of structures or equipment with the primary purpose of treating, capturing, recycling, disposing and/or preventing pollutants – treated as fixed costs, and generally annualized.

- **Operating costs**

  Include annual expenditures on salaries and wages, energy inputs, materials and supplies, purchased services, and maintenance of equipment associated with pollution abatement – treated as variable costs.
Market and surplus theory

- Basic concepts

- A market describes any situation where exchange takes place between consumers and producers

- The simplest tool economists use to illustrate consumers’ and producers’ behavior is a market diagram with supply and demand curves
Demand curve

Price

Demand

Quantity

Marginal benefit = marginal WTP

A

B

A + B = Total WTP
Supply curve

Marginal cost

Price

$P_0$

Quantity

$q_0$

C: Total costs
Competitive market

The difference between total WTPs and total costs is the largest at the intersection => economic efficiency

Producer surplus = PS, Consumer surplus = CS
Competitive market **without** the policy

Producer surplus $= PS$, Consumer surplus $= CS$
The policy

- Raises production costs
- Each unit of output is more costly to produce because of expenditures to comply with the regulation
- As a result, the industry responds by reducing the level of output
- Consequence: Upward shift of the supply curve
Competitive market with the policy

Compliance cost = A + B
Dead-weight loss = C + D
Compliance cost

- Compliance cost: Area between the two supply curves, bounded by the equilibrium output $q_1$

- Since consumers are price-sensitive (downward sloping demand curve), a higher price lead them to reduce consumption from $q_0$ to $q_1$

- If costs are estimated ex ante, and if price-sensitivity is not accounted by the analyst (so that the cost estimate is based on $q_0$), compliance costs will be overestimated [see next figure]

- Hence, compliance cost is only part of total cost. The « deadweight loss » is the additional cost from the the policy, reflecting the foregone net benefit due to the reduction in output
Competitive market with the policy

O = Overestimation of the compliance cost

Compliance cost = A + B

Dead-weight loss = C + D
Estimates of compliance costs

Compliance costs models

- Include capital costs (treatment, capture, recycling, prevention..), operating and maintenance expenditures, and costs of administration.

- Usually determined for a number of individual plants with varying baseline characteristics, and then aggregated to the industry level.

- Usually focus on the supply side, with no changes in prices.

- Example: AirControlNET (ACN): database tool for conducting pollutant emissions control strategy and costing analysis; European examples: GAINS (or RAINS; atmospheric pollution), Tremove (transport).
Social costs depend on how responsive producers and consumers’ decisions are to a change in price.

Price elasticity = \% change in the quantity resulting from a 1\% increase in price.

All else equal, an industry facing an « elastic » demand is less likely to pass on costs to consumers because increasing prices result in reduced revenues.
Elasticities (cont’d)

- Variables that may affect the elasticity of the demand schedule include i) the availability of a cheap substitute, ii) the % consumer income spent on the good, and iii) how necessary is the good for the consumer.

- Variables that may affect the elasticity of the supply schedule include i) the availability of a cheap input substitute, ii) the degree of market concentration and iii) the technological advances in production.

- Transfer method: if elasticities are drawn from previous studies, they should reflect similar i) market structure and level of aggregation, ii) economic conditions and iii) time horizons.

- Example: EPA’s Office of Air and Radiation maintains an elasticity database.
Basic principles in estimating costs

- Use market prices
  - Adjust for market distortions
- Opportunity costs
- Ignore sunk costs
- Ignore transfer payments
Dilemma: Even if the inputs consumed by a service / program / technology can be identified and quantified, it is often impossible to discern what their next best alternative uses would be.

Question: What specific goods and services are not produced when scarce resources are used to operate scrubbers, install airbags, or provide neonatal intensive care?

Economist’s Answer: The observed market price of a resource (input) is assumed to be a valid estimate of the marginal value of using that resource in its best alternative use, unless compelling evidence of market distortion is provided.
Principles of marginal cost

- S represents opportunity cost because the curve is determined by how much the suppliers of input X must be compensated to supply an additional unit of X.

- $P_e$ is a valid estimate of marginal social cost (MSC) of supplying X only for $\Delta Q$ close to 0. (Note again that S is upward sloping.) As long as the amount of an input consumed by a program is small compared to the total market for the input, any $\Delta p$ due to a program can be safely ignored. (Remember: many markets are global.)

- It is remarkably convenient that $P_e$ is the only price for X observed in the marketplace.
Adjust market prices

- If market distortions are serious, “shadow” prices for inputs should be estimated
  - Externalities
  - Monopoly
  - Unemployment
Externality (e.g., the cost of gasoline)

If negative externalities (e.g., pollution) occur in the production of the input, $P_e$ should be replaced by $P_S$, a “shadow price” that corrects for the externalities.

$$P_S = P_e + C$$
A monopoly maximizes profits by equating its marginal cost to its marginal revenue, which is below its demand schedule: the monopoly thus charges a higher price, and sells a lower total quantity, than under perfect competition.

Part of the consumers social surplus is therefore captured by the monopoly, and the equilibrium price $P_e$ does not reflect anymore marginal costs (this is the market distortion).

Hence when $P_e$ for a manufactured good (e.g., a drug) is invalid for use in BCA due to monopolistic behavior, a BCA analyst can attempt to construct the “shadow price” $P_s$ by quantifying factor inputs for the good and price them.

Example: In 1985 car companies were charging $800 for an optional, driver-side airbag system. An analysis commissioned by the government computed a “shadow price” of $200. Another example: Teflon.
Monopoly – graphical illustration

Monopoly’s marginal revenue

Monopoly’s marginal cost

Demand

Price

$p_e$

$q_e$

$q_s$

$p_s$

Quantity
Monopoly

- If $P_e$ for a manufactured good (e.g., a drug) is invalid for use in BCA due to monopolistic behavior or market disequilibrium, $P_s$ can be constructed by quantifying factor inputs for the good and price them.

- Example: In 1985 car companies were charging $800 for an optional, driver-side airbag system. An analysis commissioned by the government computed a “shadow price” of $200.
Suppose that the government invests in a project, and needs to hire new workers.

What is the cost of labor that should be imputed to this project?

Without market distortions, the unit cost of labor would be the equilibrium wage.

But, what if workers were previously unemployed? A cost of zero is inconsistent: treats time of unemployed as zero.
Opportunity costs

- What is the cost of my holidays?
  - Transportation cost + hotel (direct monetary costs)
  - But also the cost of not working (e.g., reduced salary)
  - Always needs to compare w/r to the best alternative

- What is the best alternative?
Ignoring sunk costs

- Resources that have already been consumed (or will be consumed regardless of program adoption) cannot be recovered and re-used for other purposes and are therefore excluded from opportunity cost.

- Not obvious: Imagine that you purchase a soccer game (cinema etc.) ticket but lose it just before the beginning of the game. Do you purchase another one?
Example: BCA of electric power plan

- **1998:** B=$50 M, C=$30M
  - Project is begun

- **2002:** After 4 years of construction and $40 M in costs, project is not complete. Total cost of construction is estimated to be $60 M. Should project be completed?
  - B= $50 M, C=$20M
  - Complete the Project
  - ($40M is a sunk cost)
Ignore transfer payments

- Allocation of cash from one group to another is a transfer payment and should not be included as an opportunity cost.

- Example
  - Suppose stricter enforcement of drunk driving laws causes more revenue to the government from traffic fines. Should fines be considered a cost or benefit?
  - Answer: They are transfer payment: loss to drivers exactly equals gain to government.

- Note: Some resources are consumed in administering transfer payments but these are typically tiny compared to the transfers themselves.
The “learning curve”

- Marginal costs decline with experience; Rule of thumb: Doubling cumulative output leads to a 10-30 percent decline in the marginal costs of production (Hammitt, 2003)

- Regulation boosts innovations – A classical example is SO2 regulation in the US, which implied that regulation was much less costly than previously thought (Burtraw, 2000)
The Porter Hypothesis (PH)

- Regulation increases productivity, and may eventually benefit to firms

- We get in a win-win world… Strange argument, which is not sustainable. And seemingly based on irrationality: why didn’t firms make those beneficial decisions before the regulation?

- Theoretical justification: PH possible « locally » if there exists another market failure (Ambec and Barla, EL, 2002), for instance if firms did not invest enough in R&D due to spillovers, and then do it because of the regulation
Empirical tests of PH?

- Two versions of PH: i) the *weak version* states that regulation increases innovations, and ii) the *strong version* that regulation increases economic performance.

- Weak version: validated (e.g., Jaffe and Palmer, 1997; Brunnermeir and Cohen, 2003, JEEM)

- Strong version: *not* validated (e.g., Gollop and Roberts, 1993, JPE; Lanoie et al., 2007)

- We conclude that it is useless to justify regulation by indirect and fragile arguments like the PH. A regulation must be judged on its own merits, based on its social benefits compared to its overall costs for firms in terms of economic performance.
Ex Ante vs. Ex Post Comparison: Harrington, Morgenstern, Nelson (2001)

- Surveyed 25 case studies of individual regulations - Only estimates by US government agencies (EPA and OSHA)

- Ex ante estimates of total costs have tended to exceed actuals, true for 12 out of the 25 regulations (only 6 below)

- Errors in the quantity of emission reduction

- Executive summary: “Much of the overestimation can be attributed to technical innovations unanticipated at the time the rule is issued” => Back to the debates around PH
Chapter 3. Standard Issues in BCA

- Equity
- Long term
- Uncertainty
- Bounded rationality
A longstanding debate on equity

- The issue of equity is probably the most debated issue around BCA
- The treatment of equity issues within BCA is still controversial and somewhat unsatisfactory
- See, e.g., the recent book by Adler (2010)
Aggregation across people

- “Pareto improvement”
  - “Win-win” move where everyone benefits

- “Potential Pareto improvement”
  - Or “Kaldor-Hicks compensation test”
  - Winners gain more than losers lose
  - Winners could compensate losers to make move a Pareto improvement
  - $1 gain counts equally whether it goes to me or to Bill Gates
Kaldor-Hicks criterion

- Winners and losers

- Justified by the assumption that, in the long run, everyone benefits from some decisions

- Experts in BCA are usually not experts in social justice and redistribution issues – division of tasks

- Redistribution can be better handled by other means (e.g., taxation)
  - Social welfare may be improved by transferring money from rich to poor
Kaldor-Hicks criterion (cont’d)

- Technically, maximizing WTPs (or WTAs)

- This is not the same as maximizing social welfare

- It is the case only if marginal utilities are equal across individuals, true under an optimal taxation scheme

- Problem: this criterion has given the impression that BCA may reduce social welfare, and has lead to other paradoxes

- Scitovsky (1941) showed that doing and « undoing » a policy change can be both beneficial (due to a change in the income distribution)
Should one weight WTPs?

- This can only be justified if distribution is not optimal in the society
- Different answers in the literature
- Practically, depend on how much information is available to the analyst
- One common weight is $a_i = (W/w_i)^e$ in which $W$ is average income, $w_i$ is individual or group income and $e$ is the elasticity of marginal utility. Problem: information about $e$
- US OMB recommends to complement BCA with information about the distribution of costs and benefits
Valuing future generations’ lives?

- Depends on how much we care about future lives, that is on our preferences for future generations

- Not clear because few data on individuals choices directly involving future generations
  - Important, and often unrecognized, limit of the economics approach (based on revealed preferences) for dealing with long run issues

- Standard approach: monetize future benefits, and discount them with « usual » discount rates
  - Implies (e.g.) that future VSL should be discounted
Assume that benefits and costs occurring now and in the future have been converted into money units.

- Notation $B_t$ (resp. $C_t$): Benefit (resp. Cost) in period $t$

- How to compare $B_t$ to $C_t$ at different $t$?

- Discount rate: $r$; Discount factor: $\beta=1/(1+r)$

- Net Present Value (NPV): $\sum_t \beta^t (B_t - C_t)$
Discount rates can be critical

Discount Factor = \( (1/1+r)^t \)

<table>
<thead>
<tr>
<th>Years</th>
<th>0%</th>
<th>1%</th>
<th>3%</th>
<th>7%</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>5</td>
<td>1</td>
<td>0.95</td>
<td>0.86</td>
<td>0.71</td>
</tr>
<tr>
<td>20</td>
<td>1</td>
<td>0.82</td>
<td>0.55</td>
<td>0.26</td>
</tr>
<tr>
<td>50</td>
<td>1</td>
<td>0.61</td>
<td>0.23</td>
<td>0.03</td>
</tr>
</tbody>
</table>
Reasons for discounting

Why discounting the future?

Several reasons:

1) Impatience

2) Probability to die

3) Limited altruism toward future generations

4) Growth / technical progress / learning
Which discount rate in BCA?

- Opportunity cost argument: use market rates 7-8 %

- Limits to the opportunity cost argument:
  - No long term assets (beyond 20 years) – relates to the remark about the limit of the economics approach based on revealed preferences
  - Imperfect markets
  - Uncertain growth
  - Individuals are time-inconsistent – declining discount rates over time or hyperbolic discounting
Some discount rates in practice

- US OMB traditionally specifies a 7% discount rate; proposed guidance in 2003: use of an alternative 3% and 1% for intergenerational projects

- UK Treasury (Green book): traditionally 6%, reduced to 3%

- EU guidelines for public transport infrastructures not exceed 6% (found this on the web, other references?)

- Commissariat Général du Plan in France (2005, now CAS): 7/8% for short term projects (less than 10 years), 3/4% for mid term projects and 0.5% for long term over > 50 years (as in the nuclear sector)

- Stern review on the economics of climate change: r=1.4% - derived analytically from the Ramsey rule
The Ramsey rule

- Sort of « rule of thumb » to select the social discount rate – see for example IPCC (1995, chapter 4) or Pearce and Ulph (1995)

- Social discount rate $r = a + bg$

- $a$: pure rate of time preference (Ramsey (1928) suggested $a=0$, Stern uses 0.1%)

- $b$: elasticity of marginal utility (or inverse of relative risk aversion, Stern uses 1%, i.e. a logarithmic utility function)

- $g$: rate of growth (Stern uses 1.3%, that implies for example that GDP/capita is multiplied by 13 in 2200 compared to today)
Stern Review on climate change

- Global warming equivalent to an immediate and permanent reduction of 5% of world GDP

- Nordhaus (1994) finds 3% loss of world GDP (using a 3% discount rate declining to about 1% in 300 years)
How to incorporate uncertainty in BCA?

- Sometimes uncertainties are too large to develop a « full » BCA; could give an illusion of precision

- Develop BCA on parts of the policy problem, and carefully explain what has not been included in the BCA

- But there exist many ways to account for uncertainties, and represent them into BCA
Remark: Risk aversion and WTP

- Suppose an individual may lose the amount $L$ with probability $p$; consider a policy eliminating this risk.

- What is the WTP of the individual for benefitting from the policy?

- $u(w-WTP) = (1-p)u(w) + p u(w-L)$ which implies that WTP is larger than $pL$ under risk aversion ($u$ concave).

- The WTP is thus larger than the expected loss due to risk aversion.

- Therefore, the WTP approach accounts for risk aversion toward « uncertain » losses.

- Beware of double counting.
Treatment of uncertainty in DICE

- DICE is Nordhaus (1994)’s climate-economy model with a risk averse social planner

- Sensitivity analysis over the parameters on the model – the most important uncertainties (although the ranking is ambiguous) concern population and productivity growth as well as the discount rate, and the climate sensitivity coefficient

- Monte Carlo Simulation

- Critical issue in the climate change debates: the timing of climate policy

- Uncertainty can be resolved over time => Timing of arrival of information is accounted in DICE (2000, 2020, etc.)

- Economics literature on information value, option value and the « irreversibility effect » – important but complex literature (let us present the main concepts)
Information value, an example


Investment rule: invest if $EX > c$; Expected profit: $\max(EX - c, 0)$

$\Rightarrow$ Suppose now perfect information.

Investment rule: invest if $X = x > c$; Expected profit: $E\max(X - c, 0)$

Information Value: $IV = E\max(X - c, 0) - \max(EX - c, 0) \geq 0$

Take: $c = 100$, $X = (50\%, 200, 50\%, 50)$. $IV = 50 - 25 = 25$

Take: $c = 100$, $X = (50\%, 140, 50\%, 50)$. $IV = 20 - 0 = 20$
Information and timing issues

- Information is critical in sequential decision-making

- What should I do today given that I will have better information in the future?
  - Should I wait? Should I delay decisions? Should I be more cautious?

- Most policies can be delayed. How to account for information arrival on the timing of the policy?
“Wait and See” Arguments

- DuPont spoken-person (CFC regulation, 1981): “We are going in a very long way into the regulatory process before scientists know what’s really going on”

- White House Conference (1990) (CO2 regulation): “An aggressive strategy to address possible global change based on today’s knowledge may be wholly inappropriate within a decade”
The Precautionary Principle

- Precautionary Principle at Rio Conference (1992) “Where there are threats of serious or irreversible damage, lack of full scientific certainty shall not be used as a reason for postponing cost-effective measures to prevent environmental degradation”

An example: Park vs. parking

Consider the choice between preserving a park and building a parking

There are two periods (present and future), and the discount factor is assumed to be equal to zero (to simplify)

The costs and benefits have been estimated by our best experts:

- The park yields $0 in period 1, and either $0 or $100 in period 2 with equal probability (e.g. because it may contain a rare specie with high medicine value to be potentially discovered in the future with probability 1/2)
- The parking yields $40 in each period, and costs $25

Based on BCA, the parking is built (since it yields $55 which is higher than the expected return of the park $50)

Do you agree with this choice in favor of the irreversible decision?
Bounded rationality

- Milton Friedman (economist): people make mistakes, just not systematic
- Implication: no or little macroeconomic effects
- Amos Tversky and Daniel Kahneman (psychologists): in face of complex problems, people use similar heuristics, and thus make systematic mistakes
- Remark: Kahneman (Nobel award 2002): “for having integrated insights from psychological research into economic science, especially concerning human judgment and decision-making under uncertainty”
Mistake, and policy-making

Three possible channels; mistakes:

i) can affect citizens’ WTP, which are used to evaluate public policies,

ii) may justify paternalistic policies,

iii) can be (also) made by regulators, because of bounded rationality or demagogy
Monty Hall paradox

The game (television show):
- A gift (a car) is hidden behind a door, the two other doors have no gift (a goat)
- Step 1: choose a door
- Step 2: After the choice, a door without gift (goat) is opened, should you switch?
- Answer: yes, because proba win is P=2/3 when switching, only P=1/3 when staying

Experimental studies:
- Only a minority of subjects (about 20%) switch
- Robust to repetition and feedback (Friedman 1999 AER)
- Combination of i) repetition, ii) group communication and iii) group competition needed to obtain high switching rate (Slembeck et Tyran 2004 JEBO)
Some evidence of inconsistent WTP

- Insensitivity to scale/scope
- Uncertainty effect
- Framing
(In)Sensitivity to risk reduction (results)

<table>
<thead>
<tr>
<th>Risk reduction</th>
<th>(a) 4/100,000</th>
<th>(b) 7/100,000</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean willingness to pay</td>
<td>£137</td>
<td>£155</td>
</tr>
<tr>
<td>Value of a statistical life</td>
<td>£3.4 million</td>
<td>£2.2 million</td>
</tr>
<tr>
<td>Median willingness to pay</td>
<td>£50</td>
<td>£50</td>
</tr>
<tr>
<td>Value of a statistical life</td>
<td>£1.2 million</td>
<td>£0.7 million</td>
</tr>
</tbody>
</table>

42% of respondents would pay same amount for each good (8% would pay more for the smaller good)

Source: Jones-Lee, Hammerton and Philips (1985, EJ)

See Hammitt et Graham (1999) for a meta-analysis
Uncertainty effect

- Evidence that a risky project is valued less than its worst outcome (Gneezy et al 2006)

- WTP=$38 for a gift certificate of $50, but only $28 for either a $50 or $100 certificate with 50%

- Remark: between subjects experiment (as opposed to within subjects)

- Not replicated under a different design providing more information (Rydval et al 2010)
Framing

- Preferences among lotteries should be invariant to the way the question is asked

- A counter-example: Kahneman and Tversky (1979 Etca):

  You have been given 1000. You are now asked to choose between 50% of a gain of 1000 or a sure gain of 500. (84% of subjects choose the sure gain)

  You have been given 2000. You are now asked to choose between 50% of a loss of 1000 or a sure loss of 500. (69% of subjects choose the gamble)
Some cognitive biases in psychology

- Hindsight bias
- Projection bias
- Self-serving bias
- Attribution bias
- Confirmation bias
- Cognitive dissonance
- Distinction bias
- Probability neglect
- Outcome bias
- Availability cascade
- False consensus effect
Chapter 4. Concluding Discussion

- Happiness research

- Traditional BCA handbooks refer only to two techniques for the valuation of non-market impacts
  - Revealed preferences
  - Stated preferences

- The happiness research provides an alternative third technique (HM Treasury UK 2011)
Growing literature

Figure 1: Number of EconLit journal articles with titles including the terms ‘happiness’, ‘wellbeing’, ‘well-being’ or ‘life satisfaction’, by year. The series plotted with filled circles excludes articles from the Journal of Happiness Studies.
Motivation and objective

- Motivation: The decisions made by individuals need not reveal well their preferences (e.g. bounded rationality)

- Objective: measure directly hedonic experience, often coined experienced utility (as opposed to decision utility)

- Early idea
  - Bentham interpreted utility in hedonistic term
  - Edgeworth suggested the idea of « hedonimeter »
Evidence of validity

- Happiness research uses econometric methods to estimate variables correlated with measures of happiness

- High correlates between self-reported happiness and:
  - aircarft nuisance (van Praag and Baarsma 2005)
  - activity in the left prefrontal cortex of the brain which is associated with the processing of pleasure (Urry et al 2004)
  - various objective physiological and medical criteria like a cold virus (Cohen et al. 2003), or a controlled wound (Kiecolt-Glaser et al. 2002)
Correlates with happiness

Table 1
Correlates of High Life Satisfaction and Happiness

<table>
<thead>
<tr>
<th>Correlates</th>
</tr>
</thead>
<tbody>
<tr>
<td>Smiling frequency</td>
</tr>
<tr>
<td>Smiling with the eyes (&quot;unfakeable smile&quot;)</td>
</tr>
<tr>
<td>Ratings of one’s happiness made by friends</td>
</tr>
<tr>
<td>Frequent verbal expressions of positive emotions</td>
</tr>
<tr>
<td>Sociability and extraversion</td>
</tr>
<tr>
<td>Sleep quality</td>
</tr>
<tr>
<td>Happiness of close relatives</td>
</tr>
<tr>
<td>Self-reported health</td>
</tr>
<tr>
<td>High income, and high income rank in a reference group</td>
</tr>
<tr>
<td>Active involvement in religion</td>
</tr>
<tr>
<td><em>Recent</em> positive changes of circumstances (increased income, marriage)</td>
</tr>
</tbody>
</table>

*Sources: Diener and Suh (1999), Layard (2005) and Frey and Stutzer (2002).*
How to measure happiness?

- Anticipated utility: a person’s ex ante beliefs about hedonic quality of future experiences

- Life satisfaction: a person’s retrospective assessment of her experienced utility

- Moment-based happiness
Problems with anticipated utility

- **Adaptation**
  - Mechanisms of adaptation: changing the standard of evaluation, redeployment of attention, people think about transitions not states
  - People do not anticipate they will adapt: Durability bias (Gilbert et al. 1998), affective forecasting
  - Not universal: people hardly adapt to pain and noise (Cohen et al. 1981, Weinstein 1982), and sex and food (Kahneman and Sugden 2003)

- **Focussing illusion**
  - « if you are required to think about something, you focus on it, and so you tend to exaggerate its relative importance »
  - Example: Californians are not happier, but americans believe they are (Schakde and Kahneman 1998)
Life satisfaction approach

- Most common approach

- Life satisfaction elicited based on questions such as
  - « Taken all together, how would you say things are these days? Would you say that you are very happy, pretty happy, or not too happy? » (General Social Survey)
  - « All things considered, how satisfied are you with your life as a whole these days? »

- Subjects respond using a (e.g. 5-point) scale

- World Values Survey, European Social Survey, German Socio-Economic, Panel and British Household Panel Survey
Problems with life satisfaction

- Based on memory, requires a cognitive effort

- Satisfaction is strongly sensitive to
  - trivial manipulation (dime example by Schwartz 1987; disabled person in the room by Strack et al. 1990) affecting mood,
  - order effects

- Remembered utility is different from experienced utility
  - Kahneman et al. (1993) critical finding that retrospective evaluations of past episodes of pain and discomfort place great weight on end of experience and peaks
  - « The tyranny of remembering self » (Kahneman 2007)
Moment-based happiness

- **Experience sampling method (Csikszentmihalyi 1990):**
  - collects information on people reported feeling in real time using a personal digital assistant
  - does not involve a cognitive assessment of happiness
  - Problem: intrusive

- **Day reconstruction method (Kahneman et al. 2004)**
  - ask people to fill out diaries reporting what they do and how they feel during episodes of good and bad feelings
  - now taken to be the « gold standard » in happiness (HM Treasury UK 2011)
Happiness and BCA: an example

The benefit associated with a nonmarket good can be converted into monetary value by also estimating the effect of income on happiness.

In this study (Luttmer 2005), both income and unemployment are included in the regression and are significant at 5% level. The cost of unemployment can then be estimated: around $30,000 per year (in addition to the loss of wage income that comes with unemployment).

Table 3. Example Life satisfaction regression

<table>
<thead>
<tr>
<th>Dependent variable: Life Satisfaction</th>
<th>Coefficient</th>
<th>Standard error</th>
</tr>
</thead>
<tbody>
<tr>
<td>In Household income</td>
<td>0.361**</td>
<td>0.10</td>
</tr>
<tr>
<td>Relative income</td>
<td>0.296**</td>
<td>0.08</td>
</tr>
<tr>
<td>Working hours</td>
<td>-0.138**</td>
<td>0.05</td>
</tr>
<tr>
<td>Unemployed</td>
<td>-0.355**</td>
<td>0.15</td>
</tr>
<tr>
<td>Age</td>
<td>-0.038**</td>
<td>0.01</td>
</tr>
<tr>
<td>Black</td>
<td>-0.025</td>
<td>0.07</td>
</tr>
<tr>
<td>Hispanic</td>
<td>0.297**</td>
<td>0.07</td>
</tr>
<tr>
<td>Asian</td>
<td>-0.011</td>
<td>0.12</td>
</tr>
<tr>
<td>Years of education</td>
<td>-0.006</td>
<td>0.01</td>
</tr>
<tr>
<td>In Household size</td>
<td>-0.188**</td>
<td>0.04</td>
</tr>
<tr>
<td>No religion</td>
<td>-0.162**</td>
<td>0.06</td>
</tr>
<tr>
<td>Live in a metropolitan area</td>
<td>-0.007</td>
<td>0.01</td>
</tr>
<tr>
<td>Nonmetropolitan area</td>
<td>-0.047</td>
<td>0.04</td>
</tr>
</tbody>
</table>

Note: For illustrative purposes this is just a selection of the variables used in Luttmer’s (2005) study. Significance levels: *: 10 percent; **: 5 percent. Relative income is the average income in the locality. Average (mean) income = $18,000 p.a.
Difficulties in estimating marginal utility of income

- Implausible values
  - e.g., Culture and Sport Evidence Programme UK (2010) reported a life satisfaction for going to cinema once a week of about 100 euros

- Relative income
  - and group reference effects matter a lot for happiness (e.g., Easterlin 1995, Ferrer-i-Carbonell 2005)

- Indirect effects of income
  - on variables included in the regression (health or marital status)
Happiness research

- Shows promise
  - cost and time-effective way to collect new data (exploit large national datasets with big sample size and many variables)

- But relatively new, and generates many problems
A Last Word: What BCA is Not

- BCA is NOT technocratic
  - it is based on citizens/consumers’ welfare (using individual WTP)

- BCA is a NOT a decision rule
  - it is a tool that may help the decision-making process (favors transparency, accountability, discussions among stakeholders)