CHAPTER 12: COST-BENEFIT ANALYSIS

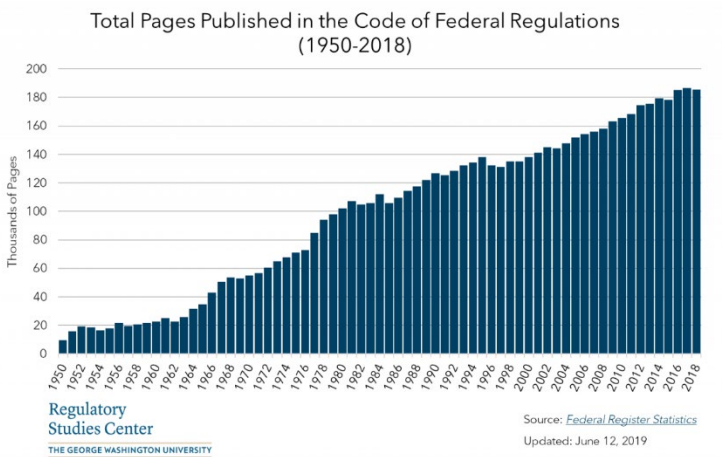
Overview

Many decisions about public health, safety, and environmental policies involve trading off money for health. For example, should car makers be required to install collision avoidance equipment that will increase the price of cars but reduce the number of accident fatalities? Cost-benefit analysis is a tool to help policy makers make these decisions. In cost-benefit analysis monetary values are assigned to benefits. This chapter describes the theory and methods that underlie the dollar values the government uses to value reductions in mortality risk and other benefits.

Regulatory impact analysis

When Congress passes a law, it is up to the executive branch departments and agencies to implement it. Laws are often vague, and so these departments and agencies have to make decisions about how they will put laws into action. The documents that describe how laws will be implemented are called regulations. There are a number of agencies that operate almost exclusively through regulations that apply to private business and individuals. These include the National Highway Traffic Safety Administration (created 1966), the Occupational Safety and Health Administration (1970), the Environmental Protection Agency (1970), the Consumer Product Safety Commission (1972), and the Nuclear Regulatory Commission (1974).

The Code of Federal Regulations has about 180,000 pages[1], covering everything to the formulae used to determine Medicare's payment to physicians to the food that farmers are allowed to feed to pigs.



[1] Regulatory Studies Center. Columbian College of Arts & Sciences. George Washington University. https://regulatorystudies.columbian.gwu.edu/reg-stats

Business groups, some academic economics, and conservatives have been concerned about the proliferation of costly regulations. They worry that government regulators face incentives to overweight the benefits and underweight the costs (to private business and individuals) of new regulations. They have pushed for agencies to conduct cost-benefit analyses before proposing regulations.

Executive Order 12044, issued by President Jimmy Carter in 1978, requires federal regulatory agencies to perform a regulatory impact analysis for any proposed regulation with an economic impact of $100 million or more (so-called "economically significant" regulations).

Building on Executive Order 12044, President Ronald Regain issued Executive Order 12291 in 1981 giving the Office of Information and Regulatory Affairs within the Office of Management and Budget the ability to reject regulations where the costs exceeded the benefits.[2] Ever since, the director of the Office of Information and Regulatory Affairs is often described as "the most powerful position in DC that no one has heard about." Since Reagan's Executive Order 12291, presidents in both parties have issued additional executive orders that re-affirm the role of cost-benefit analysis in federal regulatory policy.

President Obama appointed a strong proponent of cost-benefit analysis, University of Chicago law professor Cass Sunstein, as Office of Information and Regulatory Affairs. He also broadened the focus of the Office: in addition to considering efficiency, the Office should also consider the impact of regulations on, "equity, human dignity, fairness and distributive impacts." (Executive Order 13563; 2011).

The Supreme Court has also weighed in. The Clean Air Act says the Environmental Protection Agency may regulate mercury and other hazardous power-plant pollutants if the agency concludes action is "appropriate and necessary." In Michigan v. EPA (2015), the Court ruled, "The agency must consider cost -- including, most importantly, cost of compliance -- before deciding whether regulation is appropriate and necessary." Of course this decision was very context specific and was not a blanket endorsement of cost-benefit analysis.[3]

President Trump placed a cap on new regulations: agencies that wanted to promulgate a new regulation had to eliminate two existing ones. He also placed a cap on annual increases in regulatory costs.

One of President Biden's first actions was to release an Executive Order modifying the regulatory review process. The order, Modernizing Regulatory Review, directs the Office of

[2] For information on trends in the number of regulations requiring Office of Management and Budget review, see Carey MP. Counting Regulations: An Overview of Rulemaking, Types of Federal Regulations, and Pages in the Federal Register. *Congressional Research Service* October 4, 2016.
[3] Sinden A. Supreme Court Remains Skeptical of the "Cost-Benefit State". *The Regulatory Review* September 26, 2016.

Information and Regulatory Affairs to develop recommendations to broaden the goals of review.

> These recommendations should provide concrete suggestions on how the regulatory review process can promote public health and safety, economic growth, social welfare, racial justice, environmental stewardship, human dignity, equity, and the interests of future generations. The recommendations should also include proposals that would ensure that regulatory review serves as a tool to affirmatively promote regulations that advance these values.

The Order also seems to take the Trump administration's anti-regulatory policy in the opposite direction:

> …ensure that the review process promotes policies that reflect new developments in scientific and economic understanding, fully accounts for regulatory benefits that are difficult or impossible to quantify, and *does not have harmful anti-regulatory or deregulatory effects* [emphasis mine]

The Order gives vague guidance about quantifying distributional effects.

> …propose procedures that take into account the distributional consequences of regulations, including as part of any quantitative or qualitative analysis of the costs and benefits of regulations, to ensure that regulatory initiatives appropriately benefit and do not inappropriately burden disadvantaged, vulnerable, or marginalized communities

It is too early to tell how the Office of Information and Regulatory Affairs will change the review process and cost-benefit analysis to comply with the Order.

Pricing the priceless

Regulatory impact analysis and cost-benefit analysis more generally entail assigning dollar values to benefits. Benefits may be in the form of lives saved, injuries avoided, or, in the case of some environmental regulations, animals saved, pristine forests preserved, etc. The rest of this chapter describes methods for coming up with these dollar values. Most of the discussion is devoted to valuing deaths prevented. In regulatory impact analysis of regulations that reduce mortality risks, monetary benefits are calculated by multiplying deaths prevented by the value of a statistical life. Estimates of the value of a statistical life are usually in the $5 to $15 million dollar range.

NEWS

Kidnappers Realize They Have No Idea What Child Is Worth

4/26/06 12:13pm • SEE MORE: LOCAL

SAN YSIDRO, CA—The weekend kidnapping of 5-year-old Brendan Adler stalled Tuesday when the two men responsible for his abduction announced that they have no way to gauge the current market value of the boy.

Adler last month.

"We've run through a lot of figures, but the truth is we have no idea," said Troy Alan Curtis, the crime's primary planner. "We've been talking about anything from $1,000,000 to $10,000. It's all over the map."

The inability of Curtis and partner Steve Rodriguez to arrive at a realistic ransom figure has stymied the otherwise smooth kidnapping, which began Saturday morning when the pair snatched Adler from a local park and drove him to their abandoned-warehouse hideout. Yet four days later, the kidnappers say they are no closer to an accurate estimate of how much a boy in Adler's age and condition can fetch in the often confusing, constantly changing abductee marketplace.

Ex ante and ex post

Ex ante is a Latin phrase that roughly translates as “before the fact”. It is used to indicate a period or state of mind before uncertainty is resolved. Ex post translates as “after the fact”. It is used to indicate a period or state of mind after uncertainty is resolved.

When valuing policies that reduce mortality risk, we want to take an “ex ante” perspective. That means that we want to value the benefit that everyone derives from knowing that they face a lower mortality risk. Ex post, we will know who actually died. We are not asking the question, “How much were these individuals’ lives worth?” Another way to think about the distinction is in terms of small versus large risks. Read on.

Small versus large risks

For most public decisions, we want to focus on small risks to life. These are more relevant to public policy, where interventions have small effects on mortality risks from the standpoint of any particular individual. We are interested in “ex ante” (i.e. before the fact) valuations. A general principle of valuation is that the value of something equals the individuals’ “willingness-to-pay”. There are some circumstances where value and willingness-to-pay may diverge, but these are special cases.

The key question is: How much are you willing to pay to reduce your mortality risk by ε (where ε is some small amount)? Not: How much are you willing to pay to avoid certain death?

Most people would pay all of their wealth (including the present value of future earnings) to avoid certain death. Willingness-to-pay can never be greater than wealth. But wealth is not necessarily a good guide to individuals' willingness to pay to avoid small risks.

Suppose an individual is willing to pay $200,000 today to avoid certain death. How much should they be willing to pay for a 0.01% reduction in the risk of death? Is the answer $200,000*0.0001 = $20? Maybe, but there is no theoretical reason why this must be the case. It is not unreasonable or theoretically unsound to think that individuals might be willing to spend more than $20.

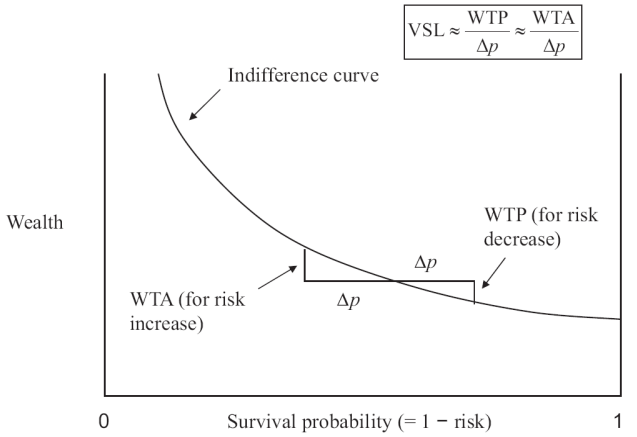


Figure 1
The trade-off between wealth and survival probability.

The figure to the right displays an indifference curve between wealth and survival risk. It is downward sloping: individuals are indifferent between a lot of wealth and a low survival probability and low wealth and a high survival probability.
From a given point, the amount of money you would be willing to pay for a small increase in your survival probability is your willingness to pay. The amount you would be willing to accept for a small decrease in your survival probability is your willingness to accept.

The Statistical Value of Life

If, on average, people are willing to spend $X to reduce the risk of death by 0.01% (or 1/10,000 or 0.0001), then the value of a statistical life is $X/0.01%. Suppose $X = $500. Then the value of a statistical life is $500/0.0001 = $5,000,000. Think about this value as representing the sum across individuals of willingness to pay to reduce risk by a small amount. Do not think about this figure as the value of a specific individual.

Estimating the value of a statistical life: market-based estimates

We observe individuals making tradeoffs between money and mortality risk in a number of different situations: what job we take, what care we buy, where we live.
Researchers study the relationship between prices and mortality risk to estimate willingness-to-pay for reducing mortality risk. For example, they may run regressions of the following form:

$$\text{Wages} = \beta^0 + \beta^1 \times \text{mortality risk} + \beta^2 \times \text{days off} + \beta^3 \times \text{time outdoors} + \ldots.$$

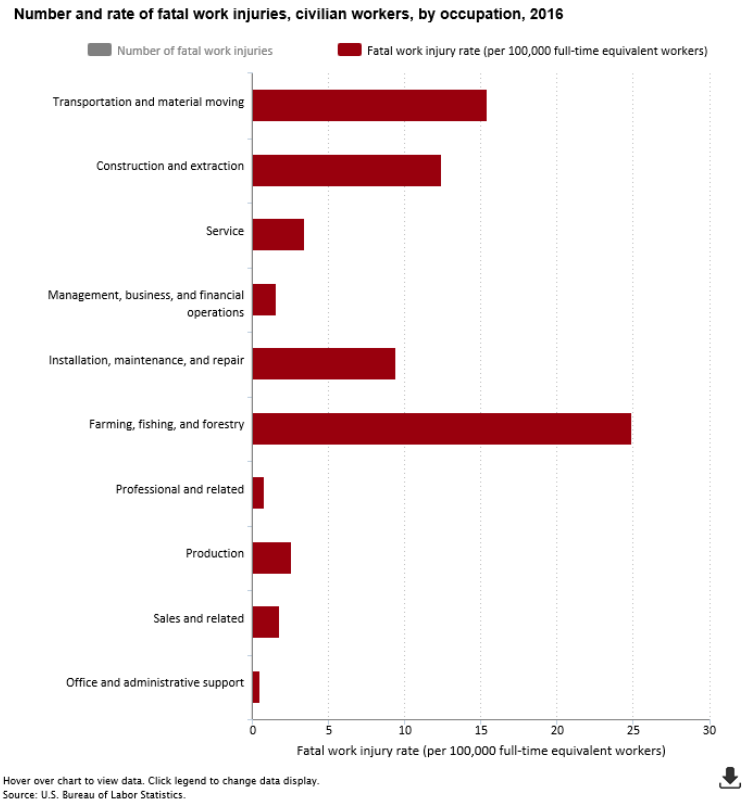
The coefficient on mortality risk is of interest and shows how much more in wages workers demand in return for accepting a higher risk of on-the-job mortality. Inclusion of other variables measuring job/industry characteristics controls for other features of jobs that may influence wages.

Approaches based on occupational choice reflect real-world behavior. People are faced with the consequences of their actions. Also, they are making choices in a familiar "decision frame".

There are also some drawbacks.

In some industries wages may not be set competitively because of labor unions or because employers are monopsonies (like a monopoly, but on the buying instead of the selling side of the market).

Estimates are valid for workers who are deciding between different types of occupations and industries, like retail versus fishing. They represent the preferences of persons "on the margin". These individuals tend to be less risk averse and have lower educational levels.



Work-related risks are not necessarily fixed, immutable characteristics of jobs. They depend on who fill the jobs. The empirical approach assumes that workers have good information about mortality risks and that researchers can accurately measure risks.

This technique measures willingness-to-pay for a specific type of risk. Willingness-to-pay may depend on the type of risk (e.g., voluntary versus not voluntary).

The validity of estimates depends on the ability to adequately control for other features of jobs.

A study that estimates the value of a statistical life using home prices

Most studies that estimate willingness-to-pay to reduce mortality risk study occupational choice, but there are studies that estimate willingness-to-pay in different contexts. For example, Lucas (2004) studied what happened to home prices in Churchill County Ohio after it became known that the county was home to a "cancer cluster".[4] He used home prices in Lyon County as a control. He found that home prices in Churchill County declined by 7.7 percent relative to prices in Lyon County. Based on the change in prices and an estimate of the increase in perceived cancer risk, he estimates that the value of a statistical life is $5.6 million.

TABLE 2—DIFFERENCE-IN-DIFFERENCE ESTIMATOR: MEAN LOG SALES PRICE BEFORE AND DURING LEUKEMIA INCREASE

	1990–1999	2000–2002	Difference
Churchill County	11.587 (0.408) $n = 2800$	11.550 (0.407) $n = 796$	−0.037
Lyon County	11.627 (0.403) $n = 4323$	11.667 (0.342) $n = 2285$	0.040
Relative difference			−0.077 (0.019)

The human capital approach

Another approach to valuing changes in mortality risk is to value changes based on earnings. This method is known as the "human capital" approach. Under this approach, the value of statistical life is set equal to the present value of earnings or the present value of earnings minus the present value of personal consumption plus the present value of taxes. The human capital approach was widely used before the development of market-based estimates (see the preceding section) and it is almost certainly wrong. It is wrong because it equates willingness-to-pay with wealth. Though wealthier individuals may be willing to pay more than poor ones for a small reduction in mortality risk, willingness-to-pay for *small* changes in mortality risks is not necessarily some fixed percentage of wealth. Your willingness to pay to reduce mortality risk by 0.001 percent is probably more than 0.001 percent of your wealth. (You might be thinking, equating willingness-to-pay with earnings or wealth is also inequitable. More on that later.)

Age and the value of a statistical life

If a proposed regulation will prevent 100 deaths, should we value the benefit differently if the population affected is young or old? You might think willingness to pay to reduce mortality risk would be higher among young individuals, who have longer to live, but studies do not report a consistent relationship between age and willingness-to-pay. Estimates may be confounded by wealth (older individuals have higher savings and income and are thus willing to pay more). The convention is to use a single value of a statistical life estimate for all regulations, regardless of the age distribution of the affected population.

The value of a (statistical) life versus the value of a year of life

Regulatory impact analysis values mortality reductions based on the value of a statistical life (a figure usually around $10 million). In the cost-effectiveness literature you may

[4] Davis LW. The Effect of Health Risk on Housing Values: Evidence from a Cancer Cluster. *American Economic Review* 2004;94(5):1693-1704.

sometimes see references to the value of a life year or value of a quality-adjusted life year, a figure usually around $100,000. This difference in approaches is partly due to convention and partly due to differences in the context in which these figures are employed. Regulatory impact analysis often deals with policies, like regulations limiting air pollution, that affect broad swaths of the population. Medical interventions on the other hand are usually targeted at a narrow segment of the population, often with limited life expectancy.

Equity and the willingness to pay principle

Market and survey data indicate that willingness to pay to avoid mortality risk varies positively with income. Should the government using a different willingness to pay standard based on the income of the affected population? Should we place a higher value on interventions to prevent airplane fatalities as opposed to motor vehicle fatalities? In practice, it does not. Federal agencies use a single figure, regardless of the characteristics of the affected population.

A related issue is whether trade agreements between the US and less developed countries should impose US health, safety, and environmental standards on firms in other countries. In effect, should we impose our willingness to pay for life on other countries where the actual willingness to pay may be lower? A related issue is the use of a constant value of a statistical life estimate in cost-benefit analyses of policies to decrease pollution in low income communities. If removing pollution causes rents to rise because the community becomes more desirable, it is possible that removing pollution could pass a cost-benefit test (using a nationwide standard) but still harm low income residents if they have a below-average willingness-to-pay.[5]

Another related issue: Should we use a higher willingness to pay for interventions that will affect future generations if we think these generations will place a higher value on safety and environment?

Value of life in the courts

Tort awards have two purposes: 1) to compensate victims 2) to deter negligent behavior. How should courts and juries determine monetary penalties?

The primary objective of awarding damages in the courts is compensation based on the principle of justice. This is an ex post perspective, and so the human capital approach, where damage are assessed based on lost earnings, is appropriate.

A secondary goal is to deter individuals and companies from presenting workers, customers, others with excessive risks in the first place from an ex ante perspective. If deterrence is the goal, courts assess penalties based on the value of a statistical life.

[5] Banzhaf, Spencer, Lala Ma, and Christopher Timmins. Environmental Justice: The Economics of Race, Place, and Pollution. *Journal of Economic Perspectives* 2019;33(1):185–208.

Courts mostly use human capital approach in practice, but value of life estimates can be useful in establishing liability (Did the defendant spend sufficient sums to avoid the accident?).

Contingent valuation

Rather than trying to back-out willingness-to-pay estimates based on market behavior, contingent valuation methods adopt a more straightforward approach: If you want to know an individual's willingness-to-pay, ask him or her. In reality, the approach is a bit more sophisticated than that, but it relies on responses to surveys rather than market behavior. Researchers who work on contingent valuation methods spend a lot of time developing question formats that they hope will elicit respondents' true willingness to pay. Willingness to pay for reductions in mortality risk could be assessed using questions of the following form.

- What is the most you would be willing to pay to avoid a 1 in 10,000 risk of death?
- "Would you accept $1,000 to move from a 1 in 10,000 chance of death to a 3 in 10,000 chance of death?"
- "Would you pay $1,000 to move from a 2 in 10,000 chance of death to a 1 in 10,000 chance of death?"
- Which of the following cars would you buy?
  Car A: Price $31,000, risk of death in a crash is 1 in 10,000
  Car B: Price is $30,000, risk of death in a crash is 2 in 10,000

Each has advantages and disadvantages.

Unlike approaches that rely on observing market behavior, contingent valuation approaches can obtain willingness to pay estimates from a much more representative sample of the population (i.e., not just workers deciding between becoming loggers or store clerks). Researchers can use contingent valuation to elicit willingness-to-pay values for non-traded goods (i.e., goods that are not priced in the market), such as endangered species.

There are, however, some important limitations to contingent valuation.

Respondents do not have to face the real-world consequences of their decisions. They are spending free money, and so they may give inflated responses, especially in situations where social desirability is a factor. Willingness-to-pay values estimated using continent valuation are not systematically higher than those estimated using market-based approaches (in the few situations where it is possible to compare them), but the concern remains. A National Oceanic and Atmospheric Administration (NOAA) expert panel on contingent valuation methods recommends dividing willingness-to-pay estimates by 2 to account for respondents' overstatement of willingness to pay.[6]

[6] Arrow, Kenneth ; Robert Solow; Paul R. Portney; Edward E. Leamer; Roy Radner; Howard Shuman. Report of the NOAA Panel on Contingent Valuation. *Federal Register* 1993;58: 4601-4614.

Respondents are not used to responding to questions that ask them to trade off money and health or other benefits. They may not give reasoned, well-informed answers as a result.

Many people have difficulty interpreting small probabilities.

Respondents may confuse willingness-to-pay with the liability for payment. Why should I pay for someone else's negligence?

Responses from contingent valuation studies display inconsistencies. For example: WTP(X) + WTP(Y) may not always equal WTP(X+Y). In Australia at one time cable companies provided customers with broadcast channels without paying anything to them. A lawsuit resulted, and a contingent valuation study was performed to determine how much the cable companies owed to the broadcast channels. The goal was to assess consumers' value for the channel. Respondents were given the choice of:
1. Paying $X per month over and above their standard cable bill to continue receiving the channels or
2. Paying nothing over and above the standard cable bill and losing the channels.

Respondents were presented with varying values of $X (Note: the choice of $X can influence the final results via the "anchoring" effect) and different bundles of channels (A: Channel 9 and SBS, B: Channel 7 and Channel 10). The results were as follows.

WTP(Bundle A) = $2.96
WTP(Bundle B) = $1.64
WTP(Bundle A and Bundle B) = $2.81

There responses were inconsistent:

WTP(Bundle A) + WTP(Bundle B) > WTP(Bundle A and Bundle B)
$4.60 > $2.81

Contingent valuation studies often include validity checks to help assess the robustness of results. For example, if you double the size of the benefit, does willingness-to-pay double

National Oceanic and Atmospheric Administration (NOAA) panel

Formed after Congress directed the Department of Commerce to write regulations governing recovery of damages following oil spills. The Department's National Oceanic and Atmospheric Administration commissioned a group of prominent economists and researchers to assess the use of contingent valuation as a method for assessing damages. The report's main conclusion was as follows.

> …The Panel concludes that CV studies [applications of the contingent valuation method] can produce estimates reliable enough to be the starting point of a judicial process of damage assessment, including lost passive-use values.

The report also included recommendations about how to administer contingent valuation studies to elicit accurate reports. These are (direct quotations follow).

- Studies should rely on personal interviews or telephone surveys rather than mail surveys.
- Applications should focus on willingness to pay to avoid a future accident, not an event that has already occurred.
- Questions should follow the "referendum" format of referring to payment in the form of higher taxes. This format most closely reflects real world decisions.
- Questions must remind respondents that by spending money on the program in question, they will have less money to spend on other things.
- Questions must reference alternative programs to accomplish the same goal.
- Surveys should include follow-up questions to test validity of answers. For example, double the benefit and see if willingness to pay nearly doubles.

Questions for thought

Suppose a proposed regulation will mainly affect mortality risks faced by low income consumers or workers. When assessing whether benefits exceed costs, should the government use an estimate of the willingness to pay to reduce mortality risks that is specific to low income consumers or workers, or use a population-wide average?

Suppose a proposed regulation will mainly affect mortality risks faced by high income consumers or workers. When assessing whether benefits exceed costs, should the government use an estimate of the willingness to pay to reduce mortality risks that is specific to high income consumers or workers, or use a population-wide average?

Supposed a proposed regulation will mainly reduce risks faced by old people. When assessing whether benefits exceed costs, should the government use a lower estimate of the willingness to pay to reduce mortality risks?

Should low income and high income countries use the same willingness to pay value to assess the benefits of regulation?

Which option should the government pursue:

Option A	Option B
Costs $250 million Benefits: $350	Costs $1 Benefits $250

Women report a higher willingness to pay than men. Should regulations that mainly affect mortality risk for men or women use different estimates of the willingness-to-pay?