Chapter 4: Valuing life and health for program evaluation.
Folland *et al* Chapter 4

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Chapter 2. We won't discuss, but you should already know:

- PPF.
- Supply and demand.
- Theory of the consumer (indifference curves etc)
- Theory of the firm (isoquants etc)
- Economic welfare.

Chapter 3. Stuff you're not expected to know:

- Classical statistical inference (hypothesis testing and all that)
- Means and variances and such like
- Simple and multiple linear regression

Efficient decision making.

- Rule (tautology?): if the benefits of X exceed the costs of X, it's efficient to do X.
- Suppose we are deciding on the level of some activity (number of hospital beds, number of Avatar BluRays, something).
- Increasing the level of the activity gives us benefits, but also imposes (opportunity) costs.
- (graph)
- MB=MC is just the Rule applied to incremental units.

Markets.

- As elaborated in the textbook, and Econ 103, and your other courses, under certain conditions the market outcome equates marginal benefits and marginal costs.
- Roughly, most economists think that markets do a pretty good job giving people the right incentives most of the time.
- But what about goods not provided by markets? e.g., in Canada, how should we decide whether to build a new hospital, or change the speed limit from 50kph to 60kph?
- Still want to equate MSC and MSB. (pollution graph)

Cost–Benefit Analysis.

- One method to help governments make good decisions is CBA.
- Requires the analyst to explicitly write down all the costs and benefits of a project.
- Should evaluate those costs and benefits using best theory and evidence available.
- Benefits and costs should include all indirect and external effects.
- If benefits $>$ costs, suggests the project should go ahead, but not necessarily the only input policy makers should use.

Mortality in CBA.

- Many projects involve risks to life (# hospital beds, new highway divider, pollution abatement, smoking regulations...)
- We face a tradeoff between statistical lives saved and other ends.
- We have no choice but to explicitly or implicitly put a value on life!

Example.

- Building a new overpass is expected to avert five deaths per year.
- The overpass costs $20,000,000. If you think we should not build the overpass, you implicitly think the value of a life is no greater than $4M.
- How high would the costs have to be before you think we should not build the overpass? You are placing a value on life.
- Really, you are placing a value on the *cost of averting a statistical death.*
- (lives saved vs other outcomes PPF graph)

Measuring the value of statistical life.

- One way: We can assess the willingness to pay some people place on their safety.
- For example, compare two (through statistical modeling) otherwise identical jobs, estimate the wage premium accruing to the more dangerous job.
- e.g., more dangerous job has $1/10000$ increase in probability of death per year and pays \$500 extra per year. A population of 10,000 of these workers incurs one extra death per per year and earns \$5,000,000 per year, so they implicitly value their (statistical) lives at \$5M.

Measurement cont.

- Could also just ask people, e.g., "If you face X risk of a heart attack, what would you pay to reduce your risk to Y?" This is called "contingent valuation."
- We can see how much people are willing to pay for safety devices, e.g., airbags, again statistically holding all else equal.
- All of these methods are problematic.

Multiple programs.

- Suppose you allocate x_1 dollars on program 1 and x_2 dollars on program 2. You have a fixed budget.
- (graphs)
- Rule: health is maximized when marginal health benefit per dollar is equalized across programs.
- Otherwise, you could take a dollar away from a marginally ineffective program and give it to a marginally effective program and increase health without changing the budget.

The three cells marked with a tick indicate results which show that a program is unambiguously economically efficient. Where the net cost of the program is zero, an increase in health outcomes is being obtained at no change in health care costs. Where costs decrease, then if health outcomes either remain unchanged or increase, the program improves economic efficiency. In these last two situations, the program is described as being dominant in comparison with the alternative and a cost-effectiveness ratio is not calculated because the cost per unit of health effect is negative.

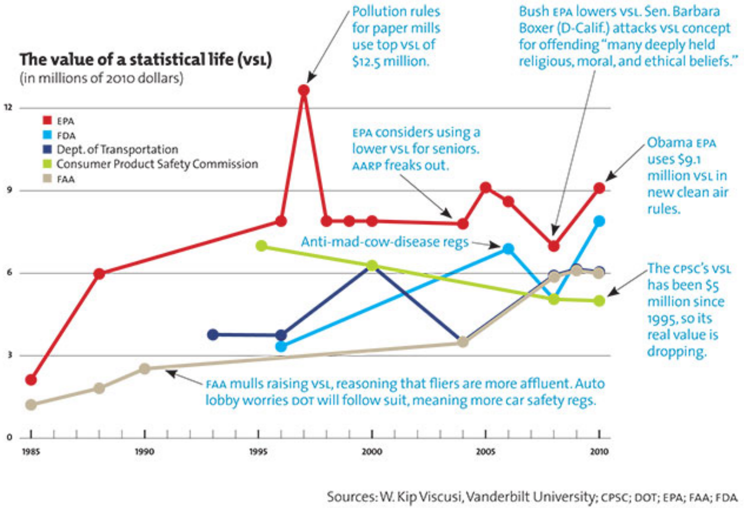
In contrast to the three cells marked with a tick, the three cells marked with a cross show that a

Table 3
Cost per life-year saved for a sample of screening programs (US dollars, 1993 prices)

Life-saving intervention	Cost per life-year saved
Breast cancer screening	
Mammography for women age 50 years	$810
Mammography every 3 years for women age 50–65 years	$2,700
Annual mammography and breast exam for women age 40–49 years	$62,000
Annual mammography for women age 55–64 years	$110,000
Cervical cancer screening	
Cervical cancer screening every 3 years for women age 65 + years	≤ $0
Cervical cancer screening every 9 (vs. 10) years for women age 30–39 years	$410
One time cervical cancer screening for women age 65 + years	$2100
Cervical cancer screening every 5 years for women age 35 + years with 3 + kids	$32,000
Annual cervical cancer screening for women beginning at age 20 years (study 1)	$82,000
Annual cervical cancer screening for women beginning at age 20 years (study 2)	$220,000
Annual (vs. every 2 years) cervical cancer screening for women age 20 years	$1,500,000
Cholesterol screening	
Cholesterol screening for boys age 10 years	$6500
Colorectal screening	
Annual stool guaiac colon cancer screening for people age 55 + years	≤ $0
One stool guaiac colon cancer screening for people age 40 + years	$660
Colonoscopy for colorectal cancer screening for people age 40 + years	$90,000
HIV / AIDS screening	
Screen blood donors for HIV	$14,000
Screen donated blood for HIV with an additional FDA-licensed test	$880,000
Hypertension screening	
Hypertension screening every 5 years for men age 45–54 years	$36,000
Hypertension screening for asymptomatic women age 60 years	$17,000
Hypertension screening for asymptomatic women age 20 years	$87,000
Newborn screening	
PKU genetic disorder screening in newborns	≤ $0

Application.

- The U.S. and Canadian governments usually use a value of about $7M as the value of a statistical life when evaluating programs.
- This means that, ignoring other effects of the program, a program is considered desirable if it costs no more than ($7,000,000)*(expected number of lives saved).
- Hopefully the effective cost of averting a death is, therefore, around $7M.


The value of a statistical life (VSL)
(in millions of 2010 dollars)
EPA
FDA
Dept. of Transportation
Consumer Product Safety Commission
FAA
Pollution rules for paper mills use top VSL of $12.5 million.
Bush EPA lowers VSL. Sen. Barbara Boxer (D-Calif.) attacks VSL concept for offending "many deeply held religious, moral, and ethical beliefs."
EPA considers using a lower VSL for seniors. AARP freaks out.
Obama EPA uses $9.1 million VSL in new clean air rules.
Anti-mad-cow-disease regs
The CPSC's VSL has been $5 million since 1995, so its real value is dropping.
FAA mulls raising VSL, reasoning that fliers are more affluent. Auto lobby worries DOT will follow suit, meaning more car safety regs.
12
9
6
3
0
1985
1990
1995
2000
2005
2010
Sources: W. Kip Viscusi, Vanderbilt University; CPSC; DOT; EPA; FAA; FDA

Examples.

- A new hospital is expected to save 50 lives per year and costs $200M per year. The hospital has no other effects. We should build it, because the cost per life saved is $4M.
- A new workplace safety regulation is expected to have a social cost of $100M per year and save 10 lives per year, and has no other effects. We should not implement the regulation, as the cost per life saved is $10M, so the opportunity cost of implementing the regulation is more than 10 lives.

Discounting.

- Exponential: If a dollar tomorrow is worth b today, then a dollar n days from now is worth b^n.
- Mathematically, the present value of one dollar tomorrow is:
$$b = \frac{1}{1+d} \tag{1}$$
where d is the daily "discount factor" and b is the present value.

Discounting cont.

- Suppose a project has a sequence of benefits and costs over time.
- In the t^{th} year, the project has net benefits of $(B_t - C_t)$.
- We discount those benefits and costs back to the present to determine the **net present value** of the project:

$$PV = \sum_{t=1}^{\infty} \frac{B_t - C_t}{(1+d)^t} \tag{2}$$

Example

- New medical imaging software costs \$100,000 today plus \$20,000 per year in licensing fees, due at the end of each year, and is expected to last two years.
- At a discount rate of d, if the software generates B of benefits per year, its net present value is:

$$NPV = -100,000 + \frac{B - 20,000}{1 + d} + \frac{B - 20,000}{(1 + d)^2} \quad (3)$$

Discounting cont.

- What rate to choose for d? For various reasons, the (real) market rate of interest is often chosen.
- Notice that $(1/(1+d)^t)$ goes to zero as t rises for any $d > 0$.
- e.g.: $d = 0.10$: $\{$ 1, 0.909, 0.826, 0.751, ... $\}$, after 100 years: 0.0000798, that is, \$1 in 100 years is worth about (7/1000) of one penny.
- At $d = 0.10$, \$1 today is equivalent to about \$6,230,000,000,000,000,000,000,000,000,000,000,000,000, about 27 orders of magnitude more than current world GDP, after 923 years.
- Discounting over long time periods is problematic!

Discounting cont.

- Many interesting ethical and theoretical issues.
- As time frames get large, discounting essentially zeros future costs and benefits.
- But not discounting also leads to strange conclusions.
- Most economists think the relevant discount rate is not zero but less than the market interest rate.

Alternatives to CBA.

- Recall CBA is a method that tells us whether to do something or not: if $B > C$, do it.
- But we have seen that measurement is a serious problem, particularly when risks to health are involved.
- We can use weaker variants of CBA which don't yield as forceful results but do not require (as) severe assumptions to work.

Cost–effectiveness analysis (CEA)

- Compare programs which generally have different costs and different amounts of the desired outcome, but do not place a monetary value on the benefits.
- e.g. Program 1 costs \$100M and is expected to save 5 lives. Program 2 costs \$100M and is expected to save 10 lives. If these programs have no other effects, then program 2 is more cost-effective than program 1.
- Notice that it might be the case that neither program has positive net benefits.

CEA cont.

- Suppose a program raises health output from E_0 to E_1, and raises costs from C_0 to C_1. Then the **CEA ratio** for this program is

$$\text{CEA ratio} = \frac{C_1 - C_0}{E_1 - E_0}. \tag{4}$$

- Example: A vaccination program is expected to save 200 lives and costs \$150M relative to the existing policy. Then its CEA ratio is (\$150M)/200 = \$750k.
- Notice that it must be possible to express outputs in the same units to use CEA.

Cost-utility analysis.

- Most programs that affect health will not just affect mortality, they will affect length and quality of life.
- We must make a tradeoff between length and quality of life.
- There are many methods analysts use to try to bring evidence to bear on this tradeoff.

QALYs

- A common method is to weight the life–years a program creates by a measure of the quality of those years.
- A year in some ill-health state is worth a proportion q of a year in perfect health, where q is (usually) between 0 and 1.
- An outcome in which a person will live for T more years in a health state "worth" fraction q_t in the t^{th} year is then evaluated

$$QALY = \sum_{t=1}^{T} \frac{q_t}{(1+d)^t} \tag{5}$$

QALYs cont

- How do we determine the q_t?
- Commonly, just ask people ("contingent evaluation" again).
- But this is done in (somewhat) clever ways.
- e.g., Might ask people to whether they would prefer a pill that cures their condition immediately with some probability q or kills then immediately with probability $(1 - q)$. Find the q that makes them indifferent to taking the pill.

QALYs cont

- We also want to take into account that different programs will generally have different effects on life expectancy.
- Suppose in the t^{th} year from now, under the program the probability the person is still alive is F_t. Then the expected number of QALYs under this program is

$$QALY = \sum_{t=1}^{T} \frac{F_t q_t}{(1+d)^t} \tag{6}$$

QALYs cont

- Example: A program causes morbidity such that in the first year quality of life is $q_1 = 0.7$. The person then has a 50% chance of surviving to year 2, if she does survive, quality of life is $q_2 = 0.3$. The person then dies with certainty ($F_3 = 0$). Then

$$QALY = \frac{0.7}{(1+d)} + \frac{(0.5)(0.3)}{(1+d)^2} \tag{7}$$

- So if $d = 0.03$, then this program produces about 0.82 QALYs.

Evaluating QALYs

- It is difficult to reconcile these approaches with standard welfare economics, even if we could perfectly measure preferences.
- We cannot perfectly measure preferences. (e.g., method discussed above confounds risk preference and preferences over health states).
- Analysis is often just shoddy (e.g., include lost wages as a "cost" in CBA or CEA).
- Discriminates against elderly, possibly against poor. Usually does not consider distributional effects (either on income or on health).