Cost Benefit Analysis

April 15, 2018

Comparing the social value of different policy projects

- Policy makers can only implement a limited number of projects. In order to implement those with highest social value one needs a common metric, a goodness measure, that can be aggregated to social value.

- Social value should be based on
  - **individualism**: the costs and benefits of a policy j on individual i should be based person $i's$ own judgement.
  - **pareto**: if policy j makes at least one person better off and no one worse off (according to their own preferences) then implementing j increases goodness or SW.
  - **welfarism**: social ordering of policies must be based exclusively on, and taken as an increasing function of, the respective collections of individual utilities of these policies.

Comparing the social value of policy projects

CBA based public policy is extremely ambitious

1. Assess the predicted effects of a policy (should be based on estimates of the causal consequences of a policy)
2. Assess how individuals value the policy consequences (assign monetary value to the consequences; find the right prices)
3. Compare losses and benefits across different individuals (Pareto is a no-brainer) (Find the right weights to aggregate individual values to a Social Value).

An Example: Environmental speed limit in Oslo

Since 2004 the speed limit at certain roads in and around Oslo has been reduced from 80 to 60 during the winter months (from 1. November) to increase air quality. Is this a good policy? CBA

Effects	How does the intervention affect: air quality, traveling time, accidents, ...
Prices	What is better air quality worth for individuals, what is reduced traveling time worth, fewer accidents
Social value	How do we weigh the lost value for those who get longer traveling time against the value for those who enjoy better air quality

Plan for the lectures

- In CBA there is not much discussion of how difficult it is to predict the effects of a policy change. It is hard to estimate policy impacts. You need a model and a clever design to estimate the parameters of that model (compare potential outcomes (with and without a policy).

- CBA centers around how to get the prices correct; when should we adjust market prices when they exist, how should we value things that are not traded (what is the value of a life, what is the value of saving ice-bears) how should we discount the future, and has should we take account of uncertainty.

- Using the right prices is important in order to assess the appropriate costs and benefits at the individual level, but the weighing function that aggregates individual values to an overall social value is also important. And the shortcuts done there often hide many important value judgments.

1. Social Welfare
2. Getting the prices right

Comparing individual values: Social welfare functions

- Estimating the effects of a policy (whether or not environmental quality, or time to travel, is altered by an environmental speed limit) and assigning how individuals value these changes are (in principle) empirical questions. Questions that can be answered with data.
- How we should weigh individual values to arrive at the social value of a policy or a project, is a normative question. This question cannot be answered with data (facts). You need "good" arguments.
- individualism and welfarism $\Longrightarrow$Social welfare $W = w(u_1, ...u_N)$ with $\frac{\partial W}{\partial u_i} > 0$.

Social Welfare

- The shape of the SW function reflects value judgements, such as the concern for equality. If social welfare is parametrized by the iso-elastic welfare function

$$W = \sum_{i=1}^{N} \left(\frac{u_i}{1-\rho} \right)^{1-\rho}$$

, ρ will capture the concern for equality. The higher ρ the more concave is the welfare function.

  - $\rho = 0 \implies$ utilitarianism: unweighted sum of utilities
  - $\rho = 0 \implies$ rawlsian: all weight on the worst off.

- individual utility is not observable. The shape of u that is used in CBA is also based on a value judgment. A key issue is to what extent marginal utility of income decreases in income.

Monetary representation of individual utility (monetary representation of policy reforms)

- One way to get a monetary representation of utility is to ask for the minimum income i needs to attain a certain utility $y_i = e(p^r, \bar{u}) : min\,(p^r x \mid u(x) \geqslant \bar{u})$ that gives $u(y_i)$ and u'' captures how marginal utility of income declines in income.

- If we assume iso-elastic utility of income $u = \left(\frac{y}{1-\alpha}\right)^{1-\alpha}$ we can write social welfare in terms of the distribution of real income in the society:

$$w = \sum_{i=1}^{N} \left(\frac{y_i}{1-\sigma}\right)^{1-\sigma}$$

  , with $\sigma = \alpha + \rho + \alpha\rho$

- If both α and ρ are large numbers, the social welfare effect of a benefit to a very rich person is small because (i) the marginal utility of income is decreasing at the personal level and (ii) marginal social welfare decreases in the income level.

Monetary representation of individual utility (allows monetary evaluation of policy reforms)

- Most CBA disregards distributional issues; assumes $\sigma = 0 \Longrightarrow$evaluates projects according to aggregate individual real income effects (does not take into account who gets the benefits and costs). Why?

- don't want to make value judgement (but assuming $\sigma = 0$) is also a value judgment.
  - separate efficiency and redistribution (implement policies that maximizes aggregate income, redistribute through tax policy)
  - if a project A generates a change in aggregate income that is positive $\sum \triangle y_i^A > 0$ this implies that the winners ***can*** in principle compensate the losers.
  - many policy projects, sometimes you win and sometimes you loose, evens out.

- none of these arguments are convincing. But it is of course very ambitious to find individual effects of policy projects.
- An alternative is to aggregate to groups (introducing a tax on suv cars will affect the buyers ($\triangle y_B$) producers ($\triangle y_S$) and the government ($\triangle y_{Gov}$).
- $\triangle w = r^b \triangle y_B + r^S \triangle y_S + r^{Gov} \triangle y_{Gov}$.

Monetary representation of individual utility (allows monetary evaluation of policy reforms)

- How do we find $\triangle y_B$?
- We can use the expenditure function. Suppose all other prices (p) (except for suv) are constant, while the after tax price for suv increases from $p^1_{suv} > p^0_{suv}$.
- $e(p, p^1_{suv}, u^0)$ is then the income suv drivers need in order to reach the welfare they had before the suv tax was introduced.$\triangle y_B(t_{suv}) = e(p, p^1_{suv}, u^0) - y^0$.
- Can also use this logic to assess the effect of forbidding suv cars.
  - $\triangle y_B$(suv forbidden) $=e(p, p^1_{suv} \to \infty, u^0) - y^0$
- Willingness to pay: Basically asking suv drivers what they would be willing to pay in order to get rid of the policy that forbids suvs. Note that if suv drivers are very rich they are willing to pay a lot to be able to drive cars with big engines (because marginal utility of income is low for them).
- If CBA disregards distributional concerns ($\sigma = 0$)$\Longrightarrow$the stated loss of the ban on suvs will be very high. Willingness to pay without weights $\Longrightarrow$systematic priority of the interests of the rich.
- Social welfare is given by $w(u_1, u_2, ...u_N)$
- if the real income effect on i and j is dy_i and dy_j the social welfare effect is $\frac{\partial w}{\partial u_i}\frac{\partial u_i}{\partial y_i} + \frac{\partial w}{\partial u_j}\frac{\partial u_j}{\partial y_j}$

CBA and the private value of a project

Suppose we want to asses the social costs and benefits of a project A, why does it differ from the commercial value of the project (if a firm implemented A). Or; why cant we use market prices to assess the social costs and benefits of a project.

1. Market prices do not reflect the true marginal costs and benefits
   - 1.1 Imperfect competition
   - 1.2 externalities
   - 1.3 tax distortions
   - 1.4 information asymmetries
2. There are no market price
   - 2.1 public goods; basic research ...
   - 2.2 travel time
   - 2.3 clean air
   - 2.4 saved lives
3. Projects may require public funds; marginal costs of public funds
4. Effects over many periods and the social discount rate may differ from private discount rate.
5. Uncertainty.

The decision rule

Suppose B_t^P and C_t^P are the true monetary benefits and costs of a project in period t. P a has a positive net present value of

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

where r is the correct discount rate to use to compare social value across time.

The decision rule is simple: If there is no constrain on the number of project that can be implemented, carry out all with $NPV > 0$. If there is a constraint on number of projects, carry out those with the highest NPV

True benefits and costs require correct prices

- P may produce goods and services and use resources that are traded in the market or effects that are not traded - where there are no market price.
- How should we price the effects. The market price is often distorted and if the good is not traded there is no price $\Longrightarrow$must calculate the true value of what is traded, find the **shadow price** (the increase in social value if one unit of this good was injected into the economy)

True benefits and costs require correct prices

Example

Project P needs 1000 workers for one year. Suppose the project draw workers from three sources.

- A fraction f^e worked elsewhere. They earned $w(1-t)$ per unit of labour (w is before tax salary and t is the tax rate)
- A fraction f^v where voluntary unemployed (looking for jobs)
- A fraction f^{iv} where involuntary unemployed.

What is the true labour costs of this project?

Social value and shadow prices

- More general point: resources required in a public project ($dz > 0$) may come from reduced consumption ($dx < 0$) or increased production ($dy > 0$). If there are tax distortions the alternative value, the shadow price, of reduced consumption and increased production are different.
- Suppose a public project needs one unit of good k. Suppose the consumer price for this good in the market is p_k . The producers get $p_k - t_k$(there is a tax distortion). If the public project reduces consumption the shadow price is p_k if the project does not reduce consumption but increases production the alternative value - shadow price - is $p_k - t_k$.
- In addition a change in price of good k may have effects in another markets j $\frac{\partial x_j}{\partial z_k} \neq 0$. If there are no distortions there there is no first order effect in social value even if $\frac{\partial x_j}{\partial z_k} \neq 0$. But if there are tax distortions (or other distortions) in market j the shadow costs must also include these indirect effects $t_j \frac{\partial x_j}{\partial z_k}$.

Shadow price of government revenue

If a project is not self financed but needs to be financed through tax revenue we need to take account of the excess burden of taxation and the fact that the marginal cost of increasing government revenue with 1 NOK is equal to $1 + \lambda$, where λ is the excess burden of taxation.

Excess burden

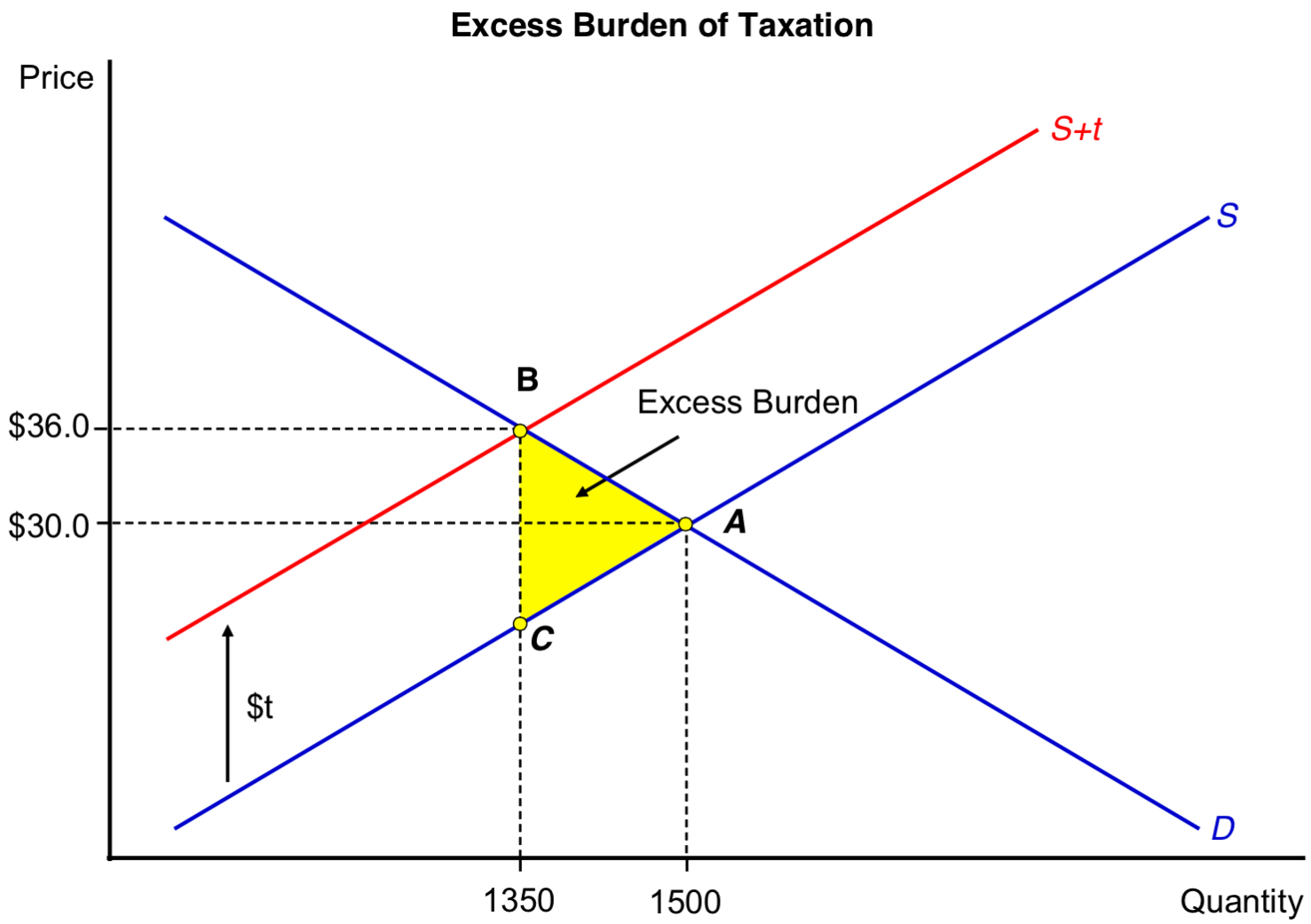
- A tax affects behavior (what we consume, how much we work, how much we save..) through two channels; by altering relative prices (sub-eff) and by reducing the purchasing power of private income and wealth (inc-eff).
- It is only the sub-eff that creates an efficiency loss. To measure EB we need to get rid of the income effects
  - an example with quasi linear utility
  - work with Hicksian (compensated) demand functions

EB in a simple case with quasi linear utility

- Two goods x and y.
- $u(x, y) = h(x) + y$ with $h(x)$ increasing and concave
- Per unit tax on good x, the tax inclusive price is $q = p + \tau$
- y is untaxed and the price is normalized to 1.
- Consumers maximize $u(x, y)$ s.t. $y + (p + \tau)x = z$
- Demand function implicitly defined by $h'(x) = (p + \tau)$
- Producers use $c(s)$ units of good y to produce s units of x; $c' > 0, c'' > 0$
- profits $\pi = ps - c(s)$ f.o.c. $p = c'(s(p))$ with elasticity $\varepsilon_S = \frac{\partial S}{\partial p}\frac{p}{S}$

EB in a simple case with quasi linear utility

illustration of the excess burden of taxation



EB in a simple case with quasilinear utility

measure excess burden

- $\text{EB} = -\frac{1}{2} d\tau dQ$
  - $dQ = S'(p)dp$
  - $dp = \left(\frac{\eta_D}{\eta_S - \eta_D}\right) dt$ to get

  $\Longrightarrow \text{EB} = -\frac{1}{2}\left(\frac{\eta_D \eta_S}{\eta_S - \eta_D}\right) pQ(\frac{d\tau}{p})^2$
- Triangle $\Rightarrow EB \to 0$ if $d\tau \to 0$. There is no first order EB effect of a very very small tax starting from a zero tax (the economic value of the transaction the tax preempted is ≈ 0)

Two important lessons

- EB increases with the square of the excise tax (more than proportional), argument for a broad tax base
- EB increases in the drop in demand caused by the tax, and this drop depend on the demand and supply elasticity. Higher taxes on inelastic tax bases.
- $\Longrightarrow$Marginal cost of public funds depend on the tax level in the economy and on the structure of the tax rates.

How to value things that do not have a price

- Same principle: Apply individuals willingness to pay (wtp) (or willingness to accept).
- Practical problems since individuals have not revealed willingness to pay in a market.
- Sometimes possible to estimate the willingness to pay based on choice data. Can use the market indirectly to assess the value
  - the value of reduced local pollution will show up in local house prices
  - less congestion, reduced travel time - can use wages to assess this effect.
  - lower risk of death - ex ante willingness to pay for this reduction. Can use the wage difference in two jobs that are equal, except a difference in risk of injuries/death.
  - Hedonic prices

Contingent Valuation

- Survey-based valuation technique
  - Survey representative sample about their WTP or their WTA for environmental goods and services.
  - Applications:
    - Benefits of improving air/water quality
    - Benefits of wilderness areas
    - Benefits of outdoor recreation opportunities

Risk

- If the benefits from a project are uncertain the expected benefits from the project will not reflect the true social value if those affected by the project are risk averse.
- The value of an uncertain project will decline in risk aversion and in the risk of the project.
- Difficult to calculate the loss related to risk; need to make assumption about the concavity of the utility function
- The government has many project, and if returns are to some extent independent the "portfolio is diversified" and the risk of one project can be ignored.

Discount rate

- What is the correct rate to discount future social benefits and costs?
- The principle is straightforward: use the discount rate used by households to compare current and future consumption.
- In a competitive market where savings do not have externalities could use the interest rate on savings
- If there are taxes on capital income, the appropriate consumption discount rate would be the after-tax return that households obtain on their savings (or pay on their borrowing).
- Externalities, liquidity constraints,... complicates things
- Hyperbolic discounting
- A big theme is intergenerational comparisons - to what extent should we take into account the welfare of unborn generations.