Economic Policy Analysis (EC406)

Course Introduction and Cost-Benefit Analysis

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Lecture Structure

(1) Course Structure
(2) Economic Policy Analysis: Overview
(3) Cost-Benefit Analysis (first lecture)
Course Structure

John Van Reenen
- MT weeks 1-5
  - Introduction, Cost-Benefit Analysis
  - Applied Econometrics Revision
  - Program evaluation
  - IV methods
  - Difference in Differences, matching

Alan Manning
- MT weeks 6-10
  - “True” experiments, regression discontinuity
  - Policy areas: e.g. immigration

Robin Burgess
- Lent Term weeks 1-10
OVERVIEW: Why study formal methods of policy evaluation?

- **Moral**  Fundamental duty of social science is to improve the world. “Until now the philosophers have only interpreted the world. The point, however, is to change it” (Marx, Theses on Feuerbach)

- **Policy advice** Type of policy advice to government often simple and impressionistic. “Evidence based government policy” more rigorous.

- **Theory testing** Using policy changes to test economic models. Most economic variables are endogenous, policy shifts sometimes a source of exogenous variation. Examples:
  - User cost of capital (R&D tax credits)
  - Price of labour (Minimum Wages and labor demand)
  - Returns to education (compulsory school leaving laws)
  - Effect of policing on reducing crime (timing of Mayoral elections)

- **Historical** Did a policy work?
Why study formal methods of policy evaluation? Difficult Issues

• General Equilibrium
  – Micro; in a particular area/group (ignore GE)
  – Nationwide; a new tax, government increase on health spending
  – International development and growth. EU, NAFTA, legal structures (Schleifer et al)

• Lucas Critique

• Political economy of policy formation. Positive theory of policies. E.g. pressure to come up with some headline grabbing policies to be seen to be “doing something”
Economic Policy Analysis: Ex ante vs. ex post

Ex ante economic policy analysis
- May be undertaken before a policy is introduced
- Combines economic theory with measures of key variables and parameters

Ex post economic policy evaluation (i.e. program evaluation, impact evaluation)
- Undertaken after a policy has been introduced
- Exploits econometric / statistical techniques to examine the effects of the policy on economic outcomes
- Focus of course is here

Course will introduce key techniques and examine their application to evaluate policies in specific contexts
Ex ante and ex post interact (e.g. use ex post to derive parameters that can be used to implement ex ante)
The key issue in evaluation: Identification

- What assumptions are needed in order to make a causal inference that one variable (e.g. policy change increasing education) affects another (e.g. individual productivity)?
- Economic Theory. This gives us some “structural” restrictions (e.g. agents are optimising; markets are perfectly competitive) that helps interpret the data. Problem is that these are generally insufficient and often not credible
- Social Experiments. Analogous to clinical trials for pharmaceuticals. One group receives the policy “treatment”, another “control” group does not (or receives a placebo). Compare before and afterwards to identify an effect. Random assignment to two groups
Identification

- **Quasi-experiments/natural experiments.** Use an exogenous event to generate treatment and control groups in an analogous way to social experiment. Often these natural experiments will be government policies, but not always. Use timing (before/after); area-based (countries, regions, cities), individuals (e.g. age groups)
Materials

• See Handout
• Practical hands-on analysis
• No single textbook – lectures and papers, Wooldridge (2003) single most useful for econometrics
Cost-benefit analysis

- Purpose is to provide a consistent procedure for evaluating decisions in terms of their consequences
- Focus on the evaluation of public sector projects (social cost-benefit analysis)
  - Develop systematic methods for evaluating the costs and benefits of policies when market prices need not fully reflect social costs and benefits
  - Explicitly incorporates information on general equilibrium (shadow prices)

Example: whether or not to build a bridge across a river that can, at present, only be crossed using a ferry
Ex Ante Policy Analysis : Cost-Benefit

Contrast with “cost effectiveness” analysis
   – Consider programs with the same (or similar) benefits, and evaluate which produces those benefits at the least cost

Example: whether to reduce lives lost by
   – freely administering a low dose of the drug lovastatin to reduce cholesterol for heart attack survivors between 55 to 94 who had a high cholesterol level
   – providing a free electrocardiogram screening test for heart disease for 40 year olds
Ex Ante Policy Analysis: Applied General Equilibrium

Applied General Equilibrium Modeling

- Numerical implementation of general equilibrium models calibrated to data
  - *Calibrate* a structural economic model to actual data on endogenous variables of interest
  - This involves the choice of key parameter values (e.g. from econometric estimates, exploiting properties of theory and data)
  - Use the calibrated model to *simulate* the effects of policy changes on endogenous variables of interest

- Applied general equilibrium model is a numerical representation of a national economy or group of economies, consisting of consumers, producers and possible a government
- Emphasis on the general equilibrium effects of policies
Ex Ante Policy Analysis : Applied General Equilibrium

Examples

- Simulate the effects of the North American Free Trade Agreement (NAFTA) on the US, Mexican and Canadian economies

- Simulate the effects of tax reform. For example, in 1986 associated with accession to the EU, Spain converted most indirect taxes to a value-added tax

- Tuition subsidies for college students
Ex Post Policy Analysis: Program Evaluation

Program evaluation

- Whether a policy or program had the intended effect on individuals, households, firms and institutions. Important because many policies have zero effect (“nothing works”)
- Whether these effects are really attributable to the program rather than other considerations
- May also explore unintended effects of the program
- Distributional issues

Central to program evaluation are the concepts of

- Treatment group (participated in the program)
- Control or comparison group (intended to be representative of the treatment group except that did not participate in the program)
Examples of Program Evaluation

Sekolah Dasar INPRES school construction program launched in Indonesia in 1973-4, evaluated in Duflo (2001)

- Between 1973-4, 61,807 new schools were constructed at a cost of about 1.5% of 1973 Indonesian GDP
- Represented more than one school per 500 children aged 5 to 14 in 1971

Minimum wages increased in New Jersey but not in neighbour state Pennsylvania. Card and Krueger Look at impact of these on low wage establishments (fast food outlets like KFC) on the borders between the state. Did employment fall?

UK “New Deal” policy to get unemployed young people into employment through more job search and wage subsidies. Introduced in some UK regions early. Blundell et al (2004) Compare young unemployed in pilot areas to young unemployed in non-pilot areas. Compare 24 year olds (treated) to 25 year olds (non-treated) in pilot areas.
Alternative Approaches to Program Evaluation

Experimental methods (randomization)
- Individuals from a well-defined group are randomly allocated to treatment and control groups

Non-experimental or quasi-experimental methods (natural experiments)
- Used to evaluate programs when it is not possible to construct treatment and control groups through experimental design
- Econometric methods used to construct a control group that resembles the treatment group as closely as possible, at least in terms of observed characteristics
- Exploit natural experiments (e.g. plausibly exogenous policy changes) which impact differentially on economic agents
Additional Examples of Program Evaluation

Randomization

- Perry pre-school experiment; JTPA, Restart; Moving to Opportunity
  - Since the mid-1990s, one third of the head positions of Indian Village Councils (Gram Panchayats) have been randomly reserved for women. Chattopadhyay and Duflo (2003) analyze the effects of reservation for women on local public goods provision
  - Unfortunately these are expensive, politically difficult and consequently, rare

Natural/”quasi” experiments

- Compulsory schooling laws in the United States generally require students to remain in school until their 16th or 17th birthdays
- Individuals born in the beginning of the year start school at an older age, and can therefore drop out after completing less schooling than individuals born near the end of the year
- Angrist and Krueger (1991) exploit this exogenous variation in schooling to estimate the rate of return to education
Quantitative and Qualitative Program Evaluation

Most of the analysis in this course will be quantitative
- Experimental or randomized control designs
- Non-experimental or quasi-experimental designs

Later in the course will also consider qualitative methods
- Focus on understanding processes, behaviour, and conditions as they are perceived by the individuals or groups being studied
- Typically survey and interview-based
- Complement quantitative methods
  - Stimulate generation of new theories
  - Provide evidence on whether the mechanisms underlying the economic or econometric model are really at work
  - Independent consistency check
  - Provide information on a wider range of economic outcomes, some of which may be hard to measure
Common Themes in Economic Policy Analysis

Determining the counterfactual?
- What would have happened had the program not been introduced

Related to identification
- Can changes in economic outcomes following a program really be attributed to the program rather than other considerations?

General equilibrium
- The introduction of a program will often have indirect effects on other groups, regions and industries which complicate evaluation
Though conceptually distinct, there are several ways in which cost-benefit analysis, applied general equilibrium analysis (AGE) and program evaluation are related. For example

- Program evaluation may yield econometric estimates that are used in subsequent AGE modeling
- The econometric estimates from program evaluation may feed into a wider cost-benefit analysis of the policy (e.g. Duflo, 2001)
- The shadow prices used in cost-benefit analysis are derived in general equilibrium, studied more explicitly in AGE analysis
Introduction to Cost-Benefit Analysis

(1) Basic approach (and example)

(2) Discounting

(3) Shadow prices

(4) Income distribution

(5) Arrow’s Impossibility Theorem

(6) Applications (in class)
   - London’s congestion charge
   - Valuing natural resources (e.g. Alaskan wildlife reserves)
(1) Cost Benefit analysis – basic analysis

- Government does social cost-benefit analysis
- Firms (and people) do private cost-benefit analysis (e.g. whether to build a steel mill)
  - Identify possible projects
  - Identify full consequences of alternatives (inputs and outputs)
  - Assign values to inputs and outputs (lifetime costs of labour and capital, evolution of steel price, costs of waste disposal)
  - Add up (opportunity) costs and benefits. Are profits positive?
  - NOTE: projects will receipts and expenditures in future years must be discounted (a Euro today is worth more than a Euro tomorrow)
Cost Benefit analysis: Discount Rates

- Discount factor ($\delta$) takes into account that future is valued less than present.

- Discount factor will depend on expected interest rates, $r$, (e.g. 10%)

$$\delta = \frac{1}{1+r}, \quad r = 0.10$$

- The Net present value (NPV) is the expected future discounted flow of profits, $x$

$$NPV = \sum_{i=0}^{\infty} \delta^i x = \frac{x}{1 - \delta}$$
Social Cost benefit analysis

• Similar to private cost-benefit analysis
• Government concerned with a broader range of consequences than profits (e.g. ecological effects of steel plant like pollution)
• Government may not always use market prices to evaluate costs of inputs and prices of outputs.
  – When outputs/inputs not sold on market (e.g. clean air, preservation of wilderness, lives saved, etc.)
  – When there are market failures prices do not reflect true marginal social costs or benefits (e.g. market power, externalities, etc.)
Example: there is a river which at present can only be crossed by ferry. The government considers whether or not to build a bridge

- Time taken to cross the river is the same
- Ferry is a privately owned monopoly and charges £0.20 per crossing, while its total costs per crossing are £0.15
- Ferry is used for 5,000 crossings per year
- Bridge would cost £30,000 (includes deadweight tax cost) to build but would be open free of charge
- It is expected that there will be 25,000 crossings per year with the bridge and that the ferry would go out of business

Should the government build the bridge?
### Cost-Benefit Analysis: Net Present Value

<table>
<thead>
<tr>
<th></th>
<th>Future net benefits per year forever</th>
<th>Area in Figure</th>
<th>Present value (10% discount rate)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ferry-owners</td>
<td>£ - 250 ((=0.05\times5000))</td>
<td>-A</td>
<td>- 2,500</td>
</tr>
<tr>
<td>Existing consumers</td>
<td>£ + 1000 ((=0.2\times5000))</td>
<td>A + B</td>
<td>+ 10,000</td>
</tr>
<tr>
<td>New consumers</td>
<td>£ + 2000 ((=0.2\times20000\times0.5))</td>
<td>C</td>
<td>+ 20,000</td>
</tr>
<tr>
<td>Taxpayers</td>
<td>—</td>
<td>—</td>
<td>- 30,000</td>
</tr>
<tr>
<td>Society</td>
<td>—</td>
<td></td>
<td>- 2,500</td>
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</tbody>
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\[
NPV = \sum_{i=0}^{\infty} \delta^i x = \frac{x}{1 - \delta}
\]

\[
\delta = \frac{1}{1+r}, \quad r = 0.10
\]
Cost-Benefit Analysis: Points to Note

**Consumer surplus**

- Difference between what an individual is willing to pay and what he has to pay

- Area under the compensated (takes income effect into account) demand curve and above the price line

**Prices charged for a project may affect its economic desirability**

- Charging a toll to cross the bridge will reduce the number of journeys and gain in consumer surplus without any corresponding reduction in cost

- Optimal price is marginal social cost per unit of output, which is zero for journeys across an uncongested bridge
(2) Cost-Benefit Analysis: Discount Rates

How to value costs and benefits at different points in time?

– with no market failures, market rate of interest reflects both opportunity cost of resources used and relative valuation of income at different dates
However, it is widely believed that there are important capital market imperfections
- Taxes introduce distortion between before and after tax rates of return

More generally, when interest rates faced by borrowers and lenders differ, should one employ:
- market interest rate
- rate of time preference of individuals (marginal rate of substitution between consumption at different points in time)
- rate of return on productive investment (opportunity cost of future production in terms of current production)

More fundamentally, how should one value the welfare of future generations?
- Consider a social welfare function defined over the welfare of various generations
(3) Cost-Benefit Analysis : Shadow Prices

What prices should be used to evaluate costs and benefits?
- Market prices may not fully reflect social opportunity costs

The shadow price of a commodity is its social opportunity cost
- The net loss (gain) associated with having one unit less (more) of the commodity
- Losses and gains have to be assessed in terms of a well-defined criterion or objective: social welfare function

Therefore, the shadow price is the increase in social welfare from the availability of an extra unit of the commodity

Social cost-benefit analysis should be based on shadow prices
- The project which makes the largest positive profits at shadow prices increases social welfare the most
Consider a ‘planner’ responsible for the evaluation of public decisions

Concerned with the effect of an extra unit of net public supplies (represented by the vector $z$) on social welfare

Net public supplies affect social welfare indirectly through variables that influence welfare at the household level (e.g. prices, wages)

- Control variables ($s$), determined within the system subject to scarcity and potentially other constraints
- Predetermined variables ($\omega$), fixed as parameters of the system

Control variables include endogenous variables of the system

- With $I$ constraints, a vector of $K$ control variables can be interpreted as consisting of $I$ endogenous variables and $(K-I)$ variables under the effective and direct control of the planner
- However, this distinction is arbitrary and both sets of variables are considered together as control variables
Cost-Benefit Analysis : Shadow Prices

Social welfare is a function of $s$ and $\omega$ and is denoted by

$$V(s, \omega)$$

Planner’s problem may be thought of as choosing $s$ to solve

$$\max V(s, \omega) \text{ s.t. } E(s, \omega) - z = 0$$

$E(s, \omega)$ : vector of net demands from the private sector
$z$ : vector of net public sector supplies

The solution to the above defines the maximum level of social welfare associated with the public sector plan $z$ (given $\omega$)

$$V^*(z, \omega)$$

The shadow price, $v_i$, of the $i$’th good is defined by

$$v_i \equiv \frac{\partial V^*}{\partial z_i}$$
$v_i$ is the increase in social welfare (evaluated at the optimum) from a unit marginal increase in $z_i$. Or the social opportunity cost in terms of social welfare of a marginal reduction in $z_i$.

Relative shadow prices correspond to marginal rates of substitution in the social welfare function $V^*(\cdot)$.

A project is a small change in public supplies, $dz$.

The value of a project $dz$ at shadow prices is

$$\sum_i v_i dz_i = dV^*$$

So a project increases social welfare if and only if it makes a profit at shadow prices (link with cost-benefit analysis).
Bergson-Samuelson social welfare function
- Individual well-being depends only on the fixed characteristics of individuals and on their consumption of commodities (so that social welfare can be defined on the commodity space)
- The marginal rate of substitution between two commodities going to the same individual is the same in the social welfare function and in the individual utility function

Consider the case of two individuals, A and B

\[ W = W(u^A, u^B) \]

For small changes

\[ \Delta W = W_{u^A} \Delta u^A + W_{u^B} \Delta u^B \]

Multiply and divide each term on right hand side by the marginal utility of a numeraire good \((v)\) to the individual concerned
Income Distribution

\[ \Delta W = W_{u^A u^A_y} \frac{\Delta u^A}{u^A_y} + W_{u^B u^B_y} \frac{\Delta u^B}{u^B_y} \]

(1) $\Delta u/\Delta u_y$: how many units of $y$ would have produced the same change in utility as the individual actually experienced.

(2) $W_{u^y_i}$ measures the social value of an extra unit of $y$ accruing to individual $i$ or the weight attached to a marginal unit of her $y$.

Decisions about these weights (including the decision to weight all individuals equally) are ultimately subjective.
(4) Income Distribution

Public policies may have very unequal effects on different individuals

**Pareto Criterion**
- A Pareto improvement is a social change from which at least one person gains and nobody loses, i.e. \( \Delta u_i > 0 \) for some \( i \), and \( \Delta u_i \geq 0 \) for all \( i \)
- A Pareto optimal state is one from which no Pareto improvement is possible

**Kaldor Criterion**
- A Kaldor improvement is a change from a given output-mix distributed in a given way to another output mix which would enable the gainers to compensate the losers while continuing to gain themselves
- Since the compensation need only be hypothetical, a Kaldor improvement offers only a potential Pareto improvement
(5) Arrow’s Impossibility Theorem

There exists no social welfare function that satisfies each of the following four axioms

- **Pareto rule**: if everyone prefers \( x^i \) to \( x^2 \), then \( x^i \) is preferable. Similarly for any other pair \((x^i, x^j)\)

- **Independent of irrelevant alternatives**: whether society is better off with \( x^1 \) or \( x^2 \) should depend only on individual preferences between \( x^1 \) and \( x^2 \) and not also on individual preferences for some other vector, for example, \( x^3 \). Similarly for any other pair \((x^i, x^j)\)

- **Unrestricted domain**: the rule must hold for all logically possible sets of preferences

- **Non-dictatorship**: we do not allow a rule whereby the ethical ordering in automatically taken to be the same as one particular individual’s preferences, irrespective of the preferences of the others
Example: Majority Voting 3 people and 3 states of world

<table>
<thead>
<tr>
<th>Person</th>
<th></th>
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<tbody>
<tr>
<td>Order</td>
<td>A</td>
<td>B</td>
<td>C</td>
</tr>
<tr>
<td>1</td>
<td>$x^1$</td>
<td>$x^2$</td>
<td>$x^3$</td>
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<td>2</td>
<td>$x^2$</td>
<td>$x^3$</td>
<td>$x^1$</td>
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<tr>
<td>3</td>
<td>$x^3$</td>
<td>$x^1$</td>
<td>$x^2$</td>
</tr>
</tbody>
</table>

**Majority voting implies**
- $W(x^1) > W(x^2)$
- $W(x^2) > W(x^3)$
- $w(x^3) > W(x^1)$
- which violates transitivity
Conclusions

Considered several approaches to economic policy analysis
- Ex ante
  - Cost-Benefit Analysis
  - Applied General Equilibrium Modeling
- Ex post
  - Program Evaluation

Cost-benefit analysis
- Basic approach
- Choice of the appropriate discount rate
- Shadow prices
- Income distribution and social welfare functions

Subsequent analysis will consider applications of cost-benefit analysis in specific contexts
Back Up
(2) Cost-Benefit Analysis: Discount Rates

How to value costs and benefits at different points in time?

- with no market failures, market rate of interest reflects both opportunity cost of resources used and relative valuation of income at different dates.
General Model: Economic Environment
[skip – see Dreze and Stern on reading list for details]

Economic agents
- \( H \) households indexed by \( h \in \{1, \ldots, H\} \)
- One private firm
- One public firm

\( I \) goods indexed by \( i \in \{1, \ldots, I\} \)

For simplicity, no externalities

Quantity constraints and public production will give rise to potential divergence between market prices and social opportunity costs

Negative supply by a firm represents demand for an input and negative demand by a consumer represents supply
General Model: Economic Environment
[skip – see Dreze and Stern on reading list for details]

Private Firms
- Faces a price vector $p$ and produces a net supply vector $y$
- May face quantity constraints with upper/lower bounds $(y_-, y_+)$
- Profit-maximizing vector of supplies $y(p, \bar{y})$
- Equilibrium pre-tax profits $\pi(p, \bar{y})$
- Profits redistributed to households with shares $\theta^h$
- Share $\zeta = 1 - \sum_h \theta^h$ received by the government

Households
- Face prices $q \equiv p + t$ where $t$ is the vector of indirect taxes
- Receive lump-sum income $m^h \equiv r^h + \theta^h \pi$ where $r^h$ is lump-sum transfer from government
- May face quantity constraints with upper/lower bounds $(x_{-h}^h, x_{+h}^h)$
- Utility-maximizing vector of demands $x^h(q, \bar{x}^h, m^h)$
- Indirect utility function $\nu^h(q, \bar{x}^h, m^h)$
General Model: Economic Environment
[skip – see Dreze and Stern on reading list for details]

Government
– Vector of net government supplies $z$
– Vector of net imports $n$

Scarcity constraints

$$\sum_h x^h - y - n - z = 0$$
$$p^w n - F = 0$$

Vector of control variables $s$ consists of $K$ variables draw from:

$$\{p_i, t_i, r^h, \bar{x}^h_i, \bar{y}_i, \theta^h, n_i\}$$

$i = 1, 2, ..., I$
$h = 1, 2, ..., H$

These are under planner’s control, but chosen subject to $I+I$ constraints above. The remaining variables $\omega$ in the above are pre-determined

Social welfare function

$$V(s, \omega) = W(..., v^h(q, \bar{x}^h, m^h), ...)$$
Optimum Policies, Shadow Prices and Policy Reform
[skip – see Dreze and Stern on reading list for details]

Planner’s social welfare maximization problem:

\[ L(s, \omega, z, F, \lambda, \mu) \equiv V(s, \omega) - \lambda \left[ E(s, \omega) - z \right] - \mu \left[ p^w n - F \right] \]

First-order conditions for control variables other than net imports:

\[ \frac{\partial L}{\partial s_k} = \frac{\partial V}{\partial s_k} - \lambda \frac{\partial E}{\partial s_k} = 0 \]

These, together with those for net imports, provide \( K \) first-order conditions which together with the \( I+I \) scarcity constraints determine:

- Values of \( K \) control variables, \( s_k \), at the optimum
- \( I+I \) Lagrange multipliers
Shadow Prices
[skip – see Dreze and Stern on reading list for details]

Lagrange multiplier equals gradient of the maximum value of the objective function with respect to a change in the variable on the right-hand side of the constraint (shadow price)

\[ \lambda \equiv \frac{\partial L}{\partial z} \equiv \frac{\partial V^*}{\partial z} \equiv v \]

Taking account of the fact that we have written the foreign exchange constraint separately

Cost-benefit test for whether a project should be undertaken:

\[ \sum_{i=1}^{l} v_i dz_i + \mu dF > 0 \]
Consider a shift in one of the parameters $\omega$ previously outside the control of the planner

$$\frac{\partial V^*}{\partial \omega_k} \equiv \frac{\partial L}{\partial \omega_k} \equiv \frac{\partial V}{\partial \omega_k} - \nu \frac{\partial E}{\partial \omega_k}$$

Evaluate a policy reform in terms of
- The direct effect on social welfare (first term)
- The cost at shadow prices of the extra demands created by the policy reform (second term)

Employ this conceptual framework to evaluate a series of different public policies (see Dreze and Stern)