1.040 Project Management

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Cost Benefit Analysis

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Outline

- What is cost benefit analysis?
- Why should we use CBA as oppose to NPV?
- What are the complexity of CBA?
- Issue of consumer surplus and its role in determination of social benefit
- Example of cost benefit analysis

Public Projects

- Public projects are those that are undertaken by government. Their objective is not necessarily to maximize profit or NPV as discussed earlier
- The main objective of public projects is to maximize social benefits and return to the society
- Problem arises regarding quantification of benefits and costs. Often there is no tradable market for public goods (parks, environmental clean up, non-toll road) or even if there is, it does not reflect the true value to the society (public education, public transportation).
- Method used for the evaluation of project from public point of view (as oppose to private firm which looks purely from private value creation for owner/stockholders) is called Cost-Benefit Analysis (value creation for society).

Cost Benefit Analysis

- "Cost-Benefit Analysis *is a* procedure for evaluating the desirability of a project by weighting benefits against costs. Results may be expressed in different ways, including internal rate of return, net present value and benefit-cost ratio." Guide to Cost-Benefit Analysis of Major Projects, In the context of EC Regional Policy, 1997 edition, European Union

- European Union Identify step necessary for Cost-Benefit Analysis for major projects:

  1 Project identification

  2 Definition of objectives (unemployment, economic growth, reduce regional income inequality)

  3 Feasibility and option analysis

  4 Financial analysis

  5 Socio-economic costs

  6 Socio-economic benefits

  7 Discounting

  8 Economic rate of return

  9 Other evaluation criteria

  10 Sensitivity and risk analysis

Expected financial internal rates of return of a sample of 400 major projects of the 'first generation' and 'second generation' combined

	average	*Number* of projects*
Energy	7.0	6
Water and environment	-0.1	15
Transport	6.5	55
Industry	19.0	68
Other services	4.2	5
TOTAL	11.5	149

(*) Projects for which data were available.

Time horizon (years) in the appraisal of a sample of 400 major projects of the 'first generation' and 'second generation' combined

	average time horizon	*Number* of projects*
Energy	24.7	9
Water and environment	29.1	47
Transport	26.6	127
Industry	8.8	96
Other services	14.2	10
TOTAL	20.1	289

(*) Projects for which data were available.

Source: Guide to Cost-Benefit Analysis of Major Projects, In the context of EC Regional Policy, 1997 edition, European Union

Why Cost-Benefit Analysis

- Objective of investment may not necessarily be profit, but other factors such as job creation (interesting to consider current stimulus package).
- In public goods, for example non-toll highway, since no payment is taking place, evaluation must be based on other alternative.
- For public goods, evaluation benefits is in terms of non monetary returns. The gain from an investment is for the society and not for investors.
- The issue is how best to quantify the benefits other than monetary benefits from particular investment. <u>Yet all those benefits must be put in a monetary term for comparison purposes</u>
- In NPV and IRR costs are both explicit. However, implicit cost and benefits, namely social costs are not taken into account. For example environmental impact of private investment often is not taken into account.

- A number of issues emerges regarding decision for public goods:
  - How do we decide on the return on public goods if they are not traded (can we find a similar trade-able good such as a similar toll road ?)
  - If the government charges a fee for use of public goods, what should be the fee? (for example, what is proper level of toll government collects?). After all in many cases government or the owner of public goods (even in the case of privatized toll road) has a monopoly power and therefore it can exploit this power.
  - What is the distributive effect of government subsidizing use of public good (or taxing it)? For example if a highway is build with tax money, but I never get to use that highway, why should I pay for it?
  - What is the externality of public goods (construction of a highway)? That is the businesses around the highway benefit from increase activities leading to increase in taxes

- What rate of discount should be used in the calculation
- Some of the decision on pubic goods could be politically motivated. The two critical issues are prices and decision to investment.
- For example, price of water, electricity, toll and bridges, tuition on public universities are all political decision and are not fully driven by market forces.
- But while decisions are politically driven, they must also have economic justifications. How do we measure the economic benefits, recognizing at the same time, that social benefits exceeds private benefits (measured purely by price charge for the use of particular good).

Project type	Number of cases (N)	Average cost escalation (%)	Standard deviation	Level of significance (p)
Rail	58	44.7	38.4	<0.001
Fixed-link	33	33.8	62.4	<0.004
Road	167	20.4	29.9	<0.001
All projects	258	27.6	38.7	<0.001

Inaccuracy of transportation project cost estimates by type of project (Fixed prices).


Image by MIT OpenCourseWare.
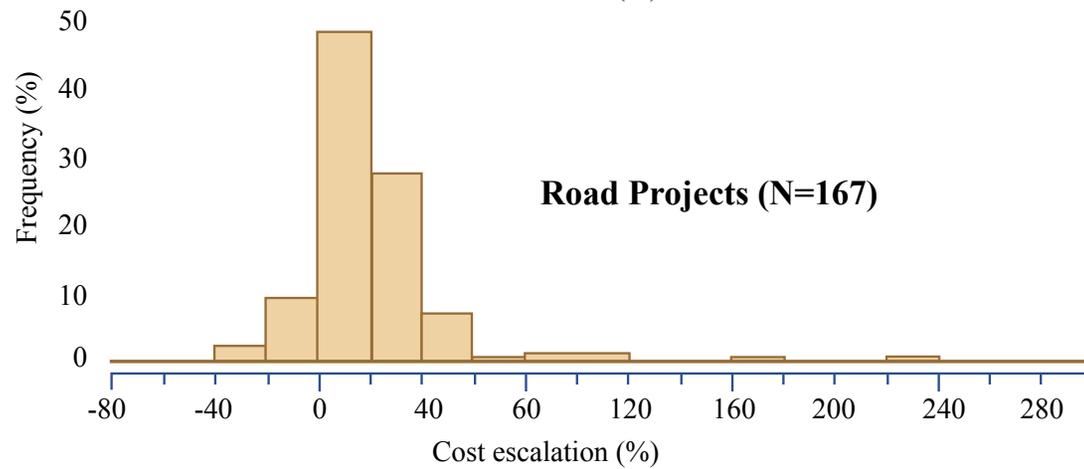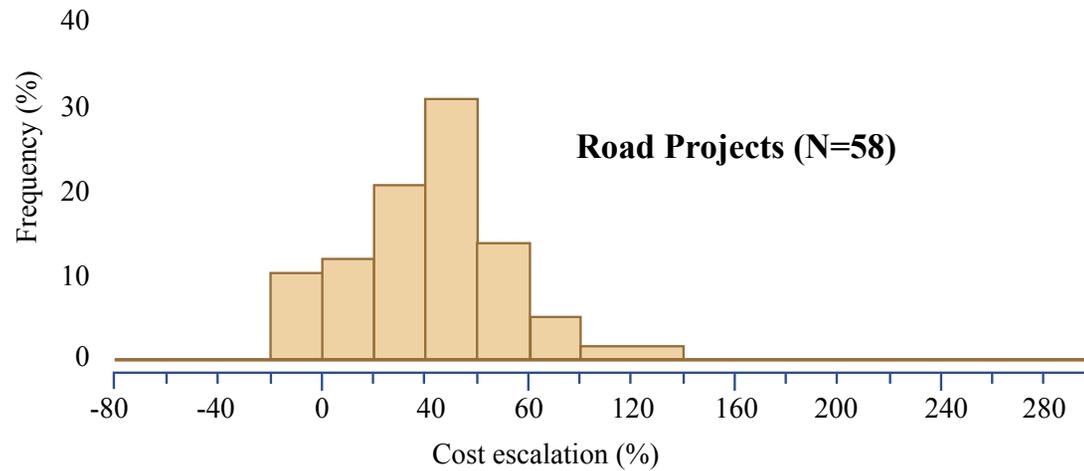
Project type	Europe			North America			Other Geographical Areas		
	Number of projects (N)	Average cost escalation (%)	Standard deviation	Number of projects (N)	Average cost escalation (%)	Standard deviation	Number of projects (N)	Average cost escalation (%)	Standard deviation
Rail	23	34.2	25.1	19	40.8	36.8	16	64.6	49.5
Fixed-links	15	43.4	52.0	18	25.7	70.5	0	–	–
Road	143	22.4	24.9	24	8.4	49.4	0	–	–
All projects	181	25.7	28.7	61	23.6	54.2	16	64.6	49.5

Inaccuracy of transportation project cost estimates by geographical locations (fixed prices).

Impact of Large Projects

- Megta projects absorb a large amount of resources with substantial impact over a long term on the prices and outputs of other sectors
  - A large project may in fact raise the labor cost for other sectors
  - It could also effect over all economic growth of country with its positive impact on the economy as a whole, leading to increase in demand for output of other sectors
  - From social point of view, government decisions must take into account these and a number of other impacts

Enumeration of Cost and Benefit

- Definition of project
  - Most of the public projects have a feed back system. For example, a highway to reduce traffic congestion may lead to increase in economic activities in that region, which cause migration to the area which in turn leads to more traffic and congestion.
  - Also, in many cases project A would effect project B either directly or sometimes indirectly through project C. For example, building of a highway may speed up traffic, but could lead to congestion in the feeder road, if they are left unimproved
  - While it is possible to see relationships mentioned above, their quantifications are not trivial and are quite difficult to estimate.

- Externalities
  - Public investment projects should take into account the external effect of their action so far as it alters the physical production possibilities of other producers or satisfaction that consumers get from resources. It should <u>not</u> take into account side effects if the sole effect is via prices of products or factors. For example, a dam has its main objective of irrigation and electricity generation. But it also may provide, free of charge, possibility for people to use the area around it for picnic. The benefit to users for picnic area is the externality. But, if there is a charge for the park, only the charge should be included in estimation.
  - Therefore externalities is when other benefits without payment is taking place as a result of particular investment.

- Secondary Benefits
  - Inducement to create other activities is considered to be secondary effect. These should be taken into account. For example irrigation system will lead to more grain production which in turn lead to series of other related activates down stream. There is debate as to whether we should use the secondary benefits. General consensus is that if the market price reflect benefit of secondary effect we should use that otherwise we must impute the value of secondary benefits (water is sold for irrigation to farmers then use the revenue).

Valuation of Cost and Benefits

- Issues relevant regarding price for the estimation of revenue.

  - Expected price of input and output should be used, but not change in the price due to over all price changes. Current price and cost may under estimate over all value (since it effects consumer and producer surplus)

  - Market prices should be used as much as possible. But what if investment is large to the extend that it changes price structure. A new power project may alter price structure of electricity and may lead to its decline. Assumption of prevailing price may over estimate revenue.

– Market Imperfection may also result in distortion of price structure. In such a case price is not reflective of social benefit of the output of the project. For example government authorities which control water supplies, would have control over price of water (since there is little or no alternative for consumer). In this case price does not reflect marginal cost of water. In such a circumstance, correction should be made both to the cost and benefit of the project to reflect the actual value.

- Also, divergence of social cost and private cost would emerge when there is unemployment in the economy. In such a circumstances any project would actually positively impacts the employment situation. Clearly the social benefits of reduction in unemployment should be added to over all benefits (relevant to Stimulus package being implemented at this time).
- There are also intangible costs and benefits of project. The intangibles are those that are either unquantifiable (such as scenic effect of a highway) or they can be quantified but is difficult to value in a market sense (life saving impact).

Choice of Discount Rate

- Use of social rate of discount presents a number of difficulties.
- Role of time and preference Private investor preference is toward a more quicker return (they are more short sighted) than public investment.
- In particular the weighted average cost of capital used by private sector as discount rate, is not applicable in the case of public project. This is because of structure of government financing through taxes and government bonds
- Government advantage in terms of having lower rate of interest than private sector. This implies that social rate of discount for the same project is lower for the government than for private sector.

Constraints

- Distributional Constraints
  - The issue of distributive effect is highly theoretical.
  - The argument is the following: since government is the agent of society it should take interest of all equally into account. Therefore, by its decision it will impact some people negatively (by taxation) and others positively by investment. This kind of decisions are not "Prato Optimal".
  - The counter argument is that if the net gain is greater than the net lose, the gainers can compensate losers and the society is left with a net positive result.

– However, since valuation of gain and loses by individuals in the society is difficult (and different), it would be difficult to determine net gain/lose through distributive impact of project on the society. (This is why some argue for a fee based approach, such as toll road, to be superior to public financed)

– The concept of Prato optimality is used in terms of distributive impact of government decisions

Social Choice

- "Prato Optimality" condition argues that if a decision makes one individual better off with out making any one worth off, then that decision is Prato optimal
  - Implication for infrastructure is that taxing and investing in infrastructure is not "Prato Optimal", while privatize development of infrastructure is, since those use the facility pay for it and are better off, while we are not taxing others

Social Choice

- Alternatively it is argued that if the decision improves the over all social benefit, even if it make some worst off it is still acceptable decision.
    - Government involvement in infrastructure through tax money, which makes some tax payers worst off but increases benefit to the society is acceptable if social benefits exceeds social cost.
- Privatized infrastructure development reduces dead weight of tax.
    - Consumer surplus will not be impacted by taxes

Budgetary Constraint

- Government has limited budget, therefore it must allocate its resources among various uses. The issues therefore include
  - Does the project provide net benefit (benefit over cost)
  - Does it provide the highest net benefit among various projects government can under take.
  - For whom does it create benefit (allocation issue)

Shadow Price

- One way to evaluate the value of public investment is through what is called shadow prices. It is an imputed value

- If our objective is to maximize economic growth, and the economy faces a number of constraint such as water, energy, telecommunication, road, how would we decide in what sector investment should go? Obviously to the sector that create the highest growth. The value that it contributes is called the shadow price of this investment.

- What if the objective is to maximize social welfare, (which is not necessary equivalent of maximizing GNP growth)? In this case it may be marginal contribution to social welfare that is the shadow price (solving a constraint optimization model). This can also be determine by the revealed preference.

- Note that with this definition, a resources that is in excess supply may even have a zero shadow price

Shadow Prices and Market Prices

- If there is no externalities and market is perfectly competitive then market price and shadow prices are equal. But there are a number of factors contribute to market failure:
  - Monopoly
  - Indirect tax
  - Unemployment
  - Property right (market can only operate if it is clear who owns what)
  - Pricing of non market item (externalities)
  - Time related choices (exhaustible resources)

Example

- To illustrate how CBA might be applied to a project, let us consider a simple highway improvement and extension. The improvement in highway leads to more capacity resulting in time saving. Data indicates that for rush hour the time cost is of a trip is $5 without project and $3 with project. It is assumed that operating cost of vehicle is unaffected by the project ($4). The project lowers the cost of trip leading to increase in number of trips. For rush hour cost saving is $2 and for non rush hour it is $0.8. Also, project is expected to reduce fatalities from 12 per year to 6.We assume value of time to be $0.1 per minute during rush hour and 0.08 during non-rush hour. Table below shows relevant data.

- Assume cost of right of way is $100 mill that can be recover at the end of the project and construction cost $200 mill during four years ($50 mill a year) and maintenance $1 mill per year. Calculate whether this project make sense if the life of project is 30 years and that bond rate is 4% with 2% inflation rate (2% real interest).

Data for Expansion of Highway

Trip	No Extension	Extension	Saving per trip
Rush hour			Difference
Passenger Trips	3000	4000	1000
Trip time (minutes)	50	30	20
Value of time per minute	0.1	0.1	0.1
Cost per trip	5	3	$2
Non Rush Hour			
Passenger Trips	500	555.5	55.5
Trip time (minutes)	35	25	10
Value of time per minute	0.08	0.08	0.08
Cost of rip	2.8	2	$0.80

	Social benefit	Annual Basis
	(Consumer Surplus)	
Rush Hour	$7,000	$10,920,000.00
Non rush Hour	$ 422.20	$ 3,039,840.00
Total benefit		$13,959,840.00

consumer surplus in Rush Hour= ((3000+4000)/2)*$2
Consumer surplus non-Rush Hour= ((500+555.5)/2)*$0.8
To annulaize Rush hour we muliply by 6 hour a day and 260 days of working week
To annualize non Rush hour we multiply 365 by 24 minus rush hour (6 hour time 260 days)

Traffic Fatalities	12	6	6
Life value			$400,000
Value of Life Saved			$2,400,000
Total Benefit include life			**$16,359,840.00**

Yearly	Benefit	Right of way cost	Construction Cost	Maintenance
year 0	0	100	0	0
Year 1-4	0	0	50	0
Year 5-29	16.36	0	0	1
year 30	16.36	-100	0	1

Assuming 2% real interest (4% interest and 2% inflation),
then NPV

Benefit	304
Right of way	-44.8
Construction	-190.4
Maintance	-18.59
Total Cost	-253.7
Total (Net benfit)	**50.3**