Institute for Transport Studies
FACULTY OF EARTH AND ENVIRONMENT

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Transport Project Appraisal - Introduction

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Outline

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1. Introduction
2. Current British practice
3. Case studies

   a – Suburban rail

   b – High speed rail

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What is project appraisal?

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Project appraisal is the assessment of the costs and benefits of different courses of action

It may look only at money costs and revenue to the agency undertaking the project (financial appraisal), or it may look more widely at costs and benefits to society as a whole and whether they take the form of cash or not (social cost-benefit analysis)

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Types of Investment in the transport sector

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Infrastructure (road, rail, sometimes ports and airports)

Public sector, subject to social cost benefit analysis

Vehicles (road vehicles, trains, aircraft, ships)

Private decision of operators based on financial appraisal (though government may influence by regulation, grants, franchise conditions etc)

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Types of investment - enhancement

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- New or upgraded infrastructure (speed, capacity)
- New improved vehicles (speed, acceleration, capacity, comfort)
- Major projects often involve packages of infrastructure and vehicles (e.g. enhancing capacity may require new track, signalling and vehicles)
- Need to check each element of the package is worthwhile

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Types of investment - replacement

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Replacement investment (relaying road surfaces or tracks, replacing signalling or vehicles

- Often projects are a mixture of replacement and enhancement (e.g. new signalling systems)
- Replacement investment needs appraisal too

- Should replacement take place?
- Does it needs the same capacity and quality?
- Is it needed immediately or can it be postponed

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Determining what investment is needed

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- Forecasting capacity needs
- Tackling specific problems (punctuality, reliability, safety)
- Identify potential benefits in terms of time savings, reliability and safety (depends both on size of saving per passenger and number of passengers affected)
- Importance of access, frequency and interchange as well as in-vehicle time (e.g. rail planning in Switzerland)

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Applications of Appraisal in the transport sector other than investments

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Rail or Bus subsidies

Franchise specification (service levels, fares)

Decisions on policy (e.g. fares regulation) and standards (e.g. safety, overcrowding)

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Principles:
appraisal frameworks

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Two philosophical frameworks:

1. Cost-benefit analysis (CBA)
   - focus is on changes in people's welfare (analogous to wellbeing)
   - everything expressed in money terms (£ or $,€...)
   - overall performance measured by Net Present Value (NPV), Benefit:Cost Ratio (BCR) or Internal Rate of Return (IRR)
2. Multi-criteria analysis (MCA)
   - multiple criteria based on objectives
   - scores for each objective often based on judgement
   - Overall weighted score with weights based on decision makers priorities

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Key differences between CBA and MCA

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- CBA uses relative weights based on willingness to pay whereas MCA uses priorities of the decision maker

- CBA estimates money values whereas MCA uses judgement

BUT can combine CBA and MCA

e.g. use of politically determined distributive weights in CBA

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How is CBA used?

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1. A decision making tool?

e.g. Is the BCR greater than 2?

2. A source of information for decisionmakers?

Needs a disaggregate presentation which is intelligible to decisionmakers.

1. May be appropriate for small and/or noncontroversial decisions.
2. Major or controversial decisions may go to the Minister.

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$$NPV_f = \sum_{i=0}^{I} \frac{(R_i - C_i)}{(1+r)^i}$$

NPV_f = Financial Net Present Value

R_i = Financial Benefits in year i (Net Revenue)

C_i = Financial Costs in year i (usually assumed that capital cost incurred in year 0, operating costs incurred in year 1 to I)

I = Project Life

r = interest rate

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Social Cost Benefit Analysis

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- NPV calculated as for commercial appraisal but including all costs and benefits whoever experiences them and whether in money terms or not
- Benefits valued in terms of willingness to pay, costs in terms of required compensation
- Weighting systems in terms of relative marginal utility of income (not currently applied to transport projects in Britain)
- Major infrastructure projects considered to have a 60 year life – but growth of benefits capped after 20 years?
- Discounted at social rate of time preference – 3.5% in Britain (3% after 30 years and lower for 75 years plus)

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Typical costs and benefits of public transport schemes

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COSTS

Capital costs

Operating costs

External costs (environment, safety)

BENEFITS

Revenue

Time savings (NB generalised time includes access, waiting, reliability, crowding)

Diversion from other modes –reduced congestion, accidents and environmental costs

Generated traffic

Wider economic benefits

Option values

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Valuing generated traffic

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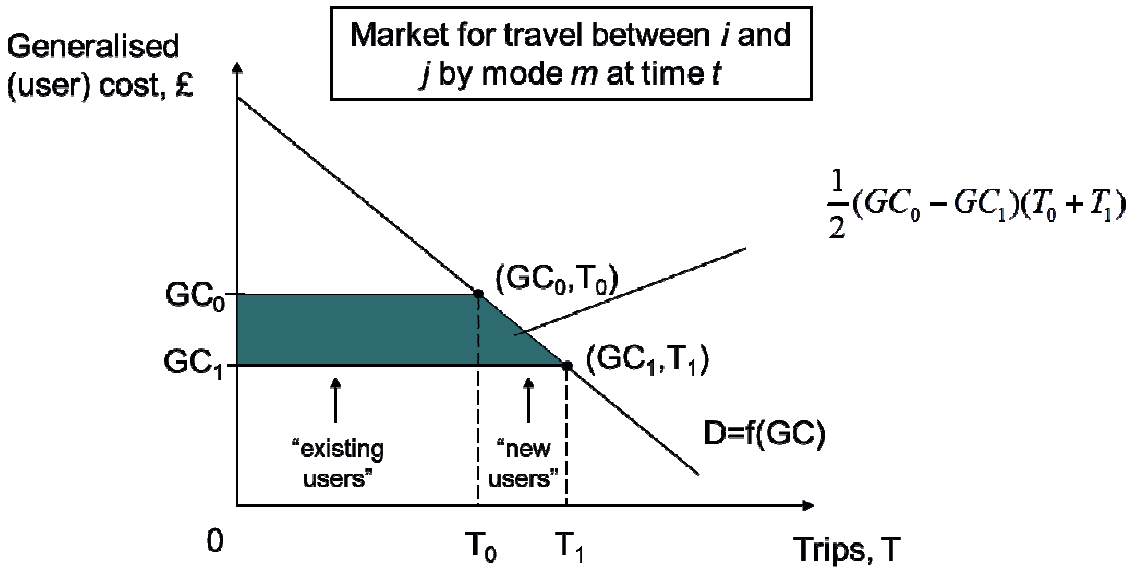
'Rule of a Half' user benefit measure:



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How might we go about making social decisions?

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- Pareto principle – if everyone is better off or at least no-one worse off then go ahead with the project

- But there will usually be winners and losers

- May try to compensate the losers (e.g.HS2 compensation scheme) – but can't fully compensate everyone

- So may actually ask whether the gainers could compensate the losers and still be better off (Kaldor-Hicks compensation test)– so does the project lead to a potential Pareto improvement in welfare?

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How are money values placed on costs and benefits?

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- Basic principle is to estimate:

- Willingness to pay for benefits

- Required compensation for costs

If willingness to pay for benefits exceeds required compensation for costs then the 'compensation test' is passed and the project could in principle make everyone better off.

However, full compensation is not usually paid and the distributive effects of the project may also be considered important.

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Use of weights in CBA – the social welfare function approach

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- A social welfare function is a function which enables us to rank all states in terms of their desirability
- A utilitarian SWF makes social welfare a function of the utility of the individuals constituting society
- W=W(Ua, Ub …)
- Popular form

$$\boldsymbol{W = \sum k_i U_i}$$

where U_i is the cardinal utility of person i and k_i is the equity weight attached to it

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Use of weighting systems

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- Poorer people generally willing to pay less and require less compensation
- A pound of benefits and costs matters more to them
- So give their benefits and costs higher weight (higher marginal utility of income - MUY)
- May believe it desirable to do more to help poorer people than this implies (equity weights) – i.e. social welfare measured not simply as sum of utilities but with more weight attached to your utility the poorer you are
- Rawls (following Gandhi) argued policies and projects should be judged solely on their impact on the poorest in society

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Quantitative Significance of Possible Weighting Systems

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w_i = weight given to income level

$$w_i = \left(\frac{Y_i}{\bar{y}} \right)^{-\beta}$$

INCOME		β	
LEVEL	0	+1	+2
¼ ỹ	1	4	16
½ ỹ	1	2	4
ỹ	1	1	1
2 ỹ	1	½	¼
4 ỹ	1	¼	1/16

i.e.

$$\Delta SW = \sum_i \Delta WTP_i w_i$$

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Basis for choice of equity weights

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- Diminishing marginal utility of income

Cannot measure – has to be based on judgement

- Equity weights

Means of deriving ethical preferences: thought experiment – what Social Welfare Function would they choose if they did not know their personal position in the resulting ordering

Harsanyi (1953; 1955) argues that people seek to maximise their expected utility so they choose the Benthamite function (which seeks to maximise sum of utilities)

Rawls argues that people adopt a maxi-min approach - so choose a function that maximises the utility of the poorest

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Difficulty of applying weights

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- Need to know who ultimately gains and loses

E.g. 1. Making a particular location more accessible may raise property values and rents.

Commuter may gain time savings but pays higher rent

Property owner may be the big gainer

E.g. 2. Reducing transport costs for goods may benefit road hauliers by reducing costs.

But in a competitive market it will be consumers ultimately who benefit

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Why use market prices in CBA?

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CBA tests whether Willingness to pay for benefits exceeds required compensation for costs.

For outputs, if consumers are free to consume as much as they choose, the will buy until P=WTP

For inputs, in a perfect market P=value of marginal product

i.e. required compensation for giving up what else the inputs might have produced

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When are market prices inappropriate?

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- Rationing
- Monopoly power

- Artificially pushes up prices relative to wages

- Externalities

- Costs or benefits imposed on third parties – not just producers and consumers

e.g. Pollution, noise, greenhouse gases.

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Discounting for Time

	Example at 10%
£1 now is worth	
1 (1+r) after 1 year	1.1
$1(1+r)^2$ after 2 years	1.21
$1(1+r)^t$ after t years	$(1.1)^t$
Or, the present value of £1	
In 1 year's time = $\frac{1}{(1+r)}$	0.91
In 2 year's time = $\frac{1}{(1+r)^2}$	0.83
In t year's time = $\frac{1}{(1+r)^t}$	$\frac{1}{(1.1)^t}$

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Importance of Discount Rate

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Weight given to costs or benefits in years

	10	20	30	40	50
5%	0.61	0.38	0.23	0.14	0.09
10%	0.39	0.15	0.06	0.02	0.01

But should we also discount for time in a social cost-benefit analysis?

1. Diminishing marginal utility of income
2. Pure time preference
3. Risk

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Estimation

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- Might use market rate – consistent with willingness to pay approach
- But most countries use Ramsey approach to estimating social time preference – consistent with a social welfare function approach
- Pure time preference plus rate of decline of marginal utility of income

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Estimation

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- w_i=weight attached to income in year i
- = marginal utility of income in year i
- i.e. $w_1 = \frac{a}{Y^b{}_1}, w_2 = \frac{a}{Y^b{}_2}$

- If real income per head is growing at rate g then:-

$$\frac{W_2}{W_1} = \frac{1}{(1+g)^b} = \frac{1}{1+s}$$

where s is the rate of social time preference and b is the elasticity of the marginal utility of income with respect to income.

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Where do the values of externalities come from?

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Commuting and leisure time

-Revealed preference models

Studies of behaviour when there are alternatives which vary in journey time and cost

-Stated preference models

Studies of choices made between hypothetical alternatives

Travel in the course of work

- Cost of labour

Wage rate plus overhead cost of employing labour

(Should this be replaced by willingness to pay? Of employers or employees?)

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Example of a stated preference question

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	Option A				
ONDON, dep	2.50	3.20	3.50	4.20	4.50
ockport…	5.10	5.40	6.10	6.40	7.10
anchester, arr.	5.20	5.50	6.20	6.20	7.20

Fares: One way £12, Return £24
Scheduled Journey Time: 2 hrs 30 mins

	Option B		
LONDON, dep	2.50	• 3.50	• 4.50
Stockport…	5.40	• 6.40	• 7.40
Manchester, arr.	5.50	• 6.50	• 7.50

Fares: One way £10, Return £20

i. Scheduled Journey Time: 3 hrs

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Accident and environmental costs

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- Based on willingness to pay for reduced risk and improved amenity (Again RP or SP)
- For accident costs, based on SP studies
- Noise costs generally based on hedonic studies of house prices
- Air pollution costs follow the impact pathway approach (dose response – forecast no of households exposed to each level of pollution)
- Greenhouse gases best handled by a shadow price of carbon based on costs of reaching targets (NB ‘tradeable’ carbon already internalized by the European emissions trading scheme)

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Conclusion

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Project appraisal may be applied to all government spending - replacements, enhancements, taxes and subsidies, franchise specifications, standards

Two possible principles behind cost benefit analysis

- Compensation test
- Maximising a social welfare function (i.e. sum of weighted willingness to pay less weighted willingness to accept compensation)

In either case will normally apply discounting for time (but the discount rate will differ)

All costs and benefits should be included (including externalities)

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References

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- As an introduction to project appraisal see

  The Green Book (2020) - GOV.UK (www.gov.uk)

  There are many good text books on cost benefit analysis.

  A recent one is

  Gines de Rus (2010) Introduction to Cost–Benefit Analysis. Edward Elgar.

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