

Imperial College
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**Cost-benefit analysis: introduction
and overview of the UK approach.**

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Summary of the talk

1. Review of the principles guiding cost-benefit analysis (CBA).
2. Outline of the UK CBA process.
3. Key components and assumptions of CBA calculations.
4. Limitations of CBA and on-going developments.
5. Assessment of Wider Economic Impacts (WEIs).
6. Examples of the use of CBA from the UK.

UK Treasury definition of CBA

*“...an analysis which **quantifies in monetary terms as many of the costs and benefits** of a proposal **as feasible**, including items for which the **market** does not provide a satisfactory measure of **economic value**.”*

UK Treasury (2003) *Appraisal and evaluation in Central Government*.

Key characteristics of CBA

- i. **Comprehensive scope** – CBA incorporates a wide range of considerations (not just financial), but not the full range that inform decisions.
- ii. **Social perspective** – CBA is based on the view that a net increase in welfare is a good thing, even if some groups within society lose out (Hicks-Kaldor assertion).
- iii. **Monetary terms** – the CBA approach ‘monetises’ costs and benefits.
- iv. **Individual valuation** – benefits and costs are measured by how individuals value them, not social planners or analysts.

CBA is a comparative tool

do-something scenario – represents some change to the transport system. Different do-something scenarios for each version of a project, or for different projects.

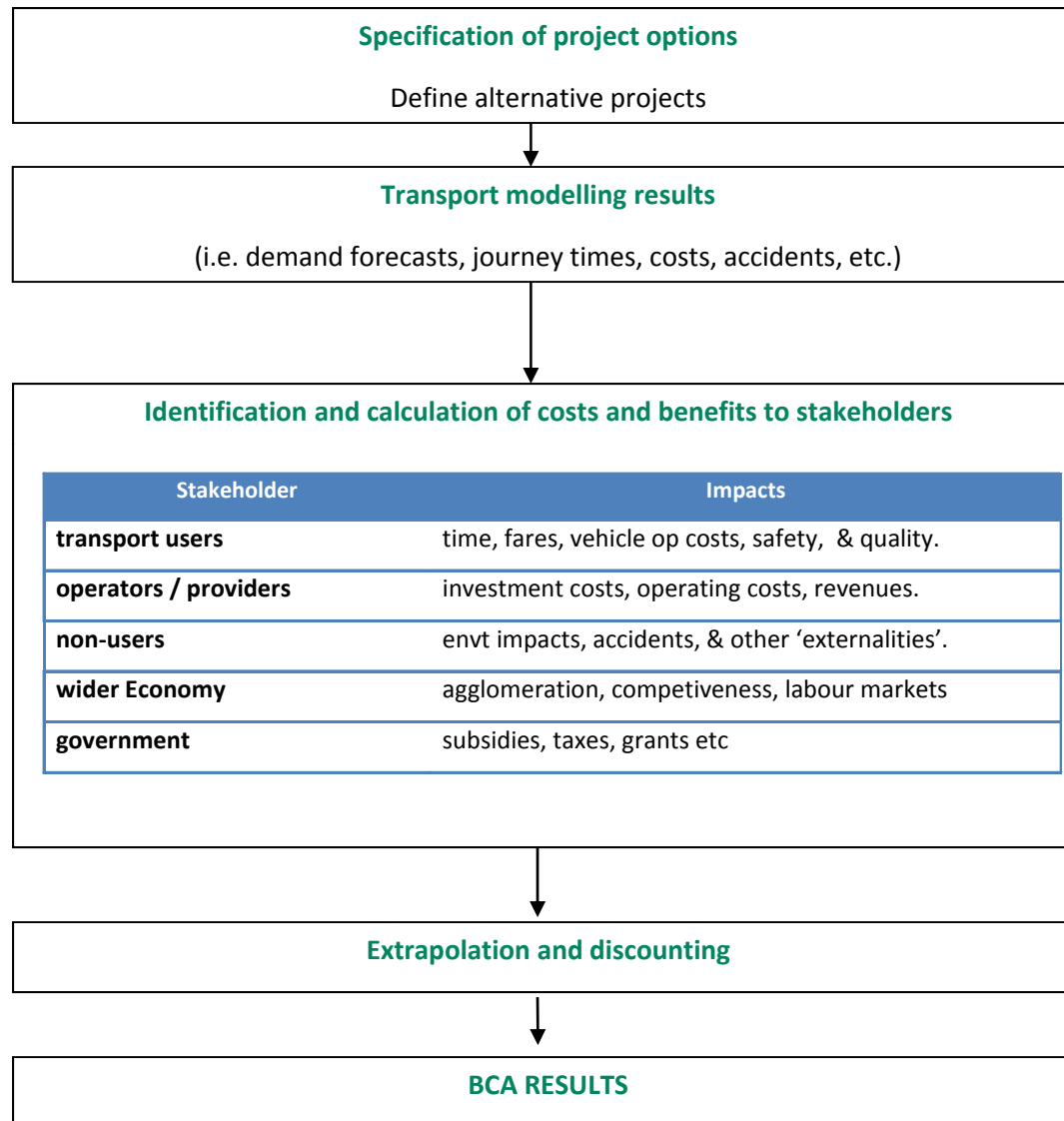
do-minimum scenario – transport system remains as it would be with no project. Realistic do-minimum should include necessary maintenance and improvement work.

Stages at which a CBA may be undertaken

1. ***ex ante CBA*** – conducted during the decision making process prior to investment. Based on predicted values to inform investment choices.
2. ***ex post CBA*** – conducted for the purpose of evaluation to inform future investment decisions. Largely based on observed values.
3. ***in medias res CBA*** – conducted during the lifetime of the project. Useful in deciding whether a project should be extended or investment re-directed.

in practice most CBAs are ex ante but ex post is valuable

Outline of the CBA process



Estimation of user benefits

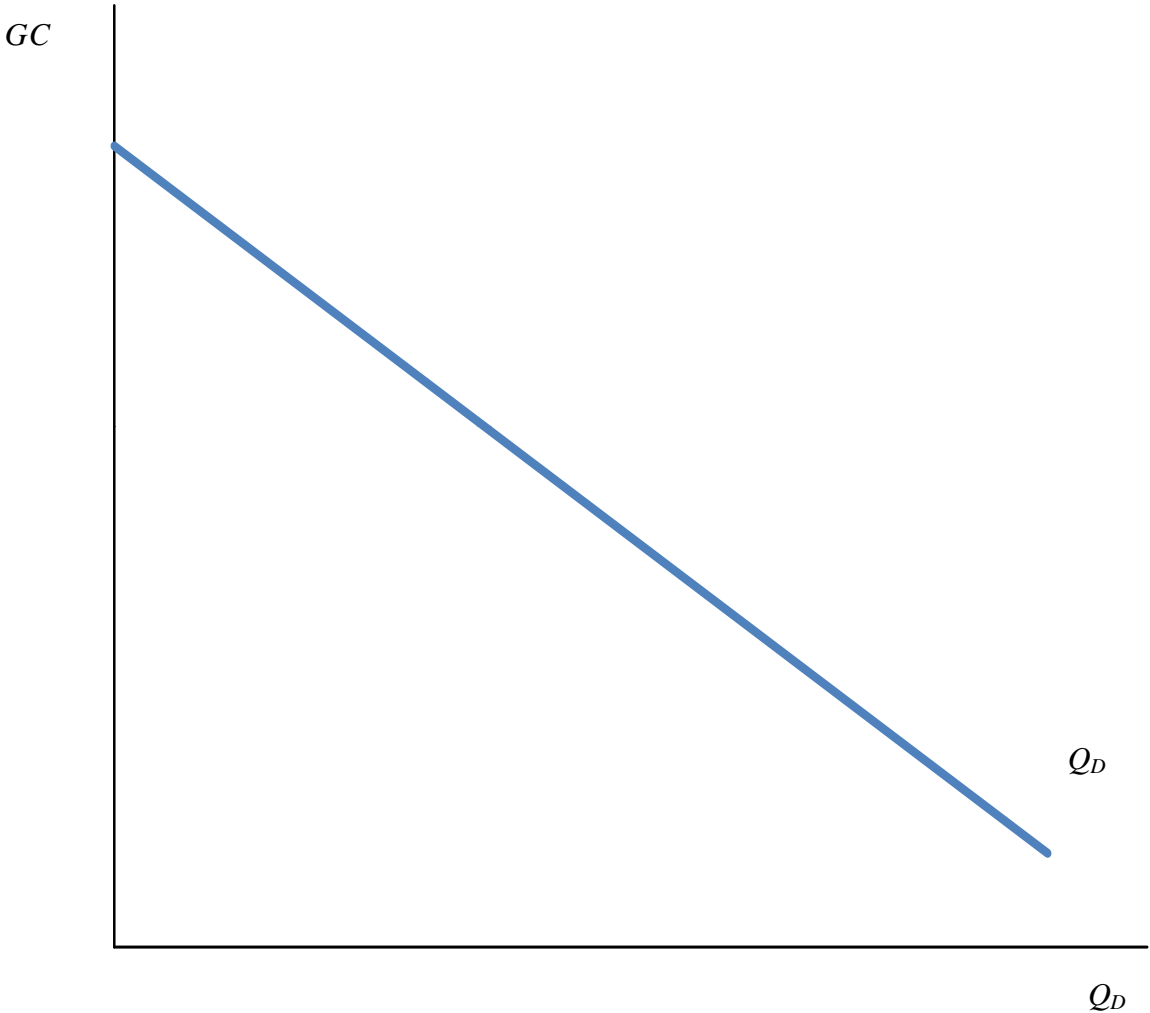
Three key concepts from the theory of demand

1. **Generalised cost (GC)** – users travelling from i to j by mode m face both monetary and non-monetary costs

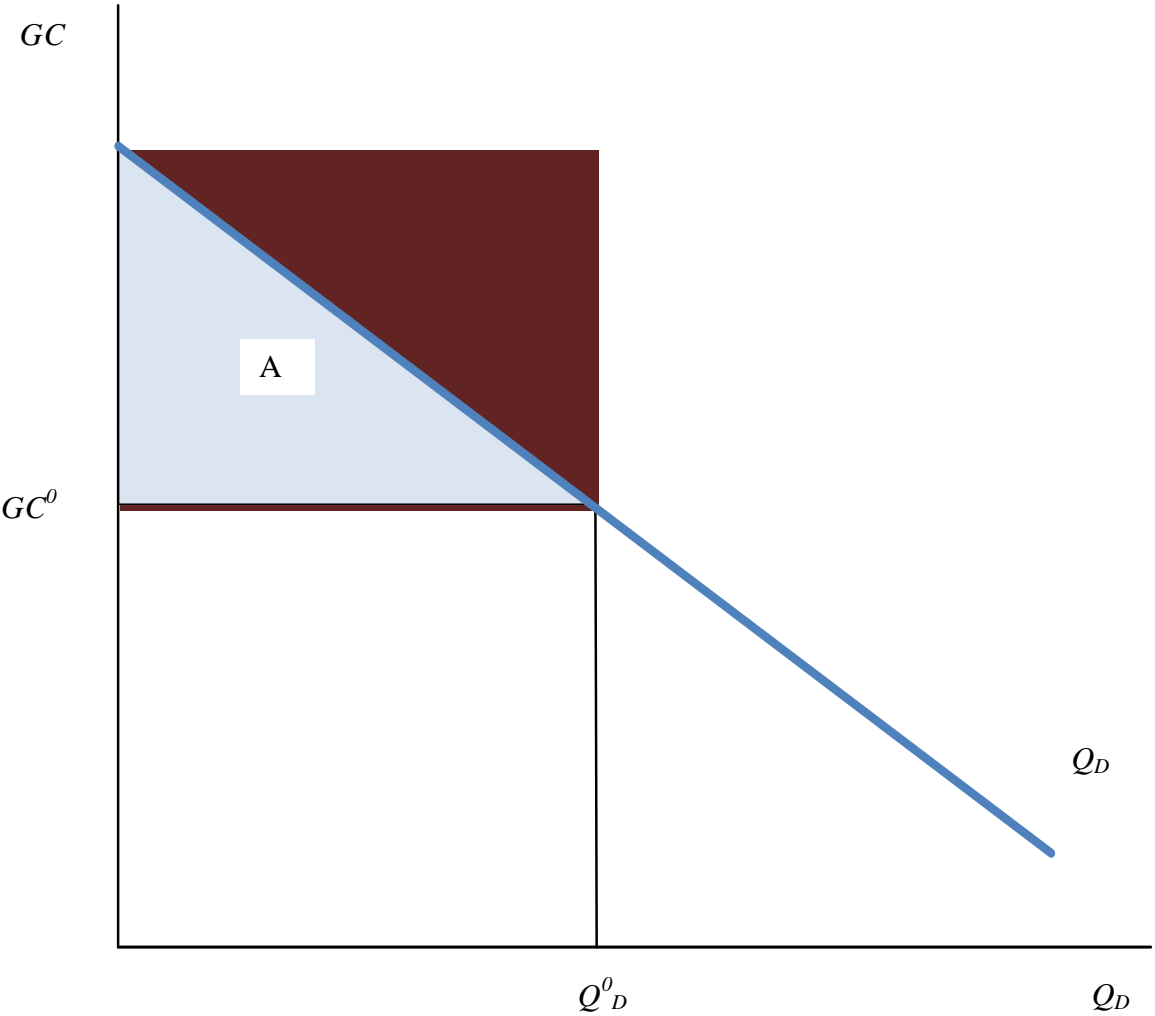
$$GC = \text{price} + \text{time cost} + \text{vehicle operating costs} + \text{other charges}$$

2. **Willingness to pay (WTP)** – each user has a maximum amount they are willing to pay to make the trip. If $WTP \geq GC$, trip is made. WTP varies by user.
3. **Consumer surplus (CS)** – is the difference between the actual GC of the trip and consumers' WTP.

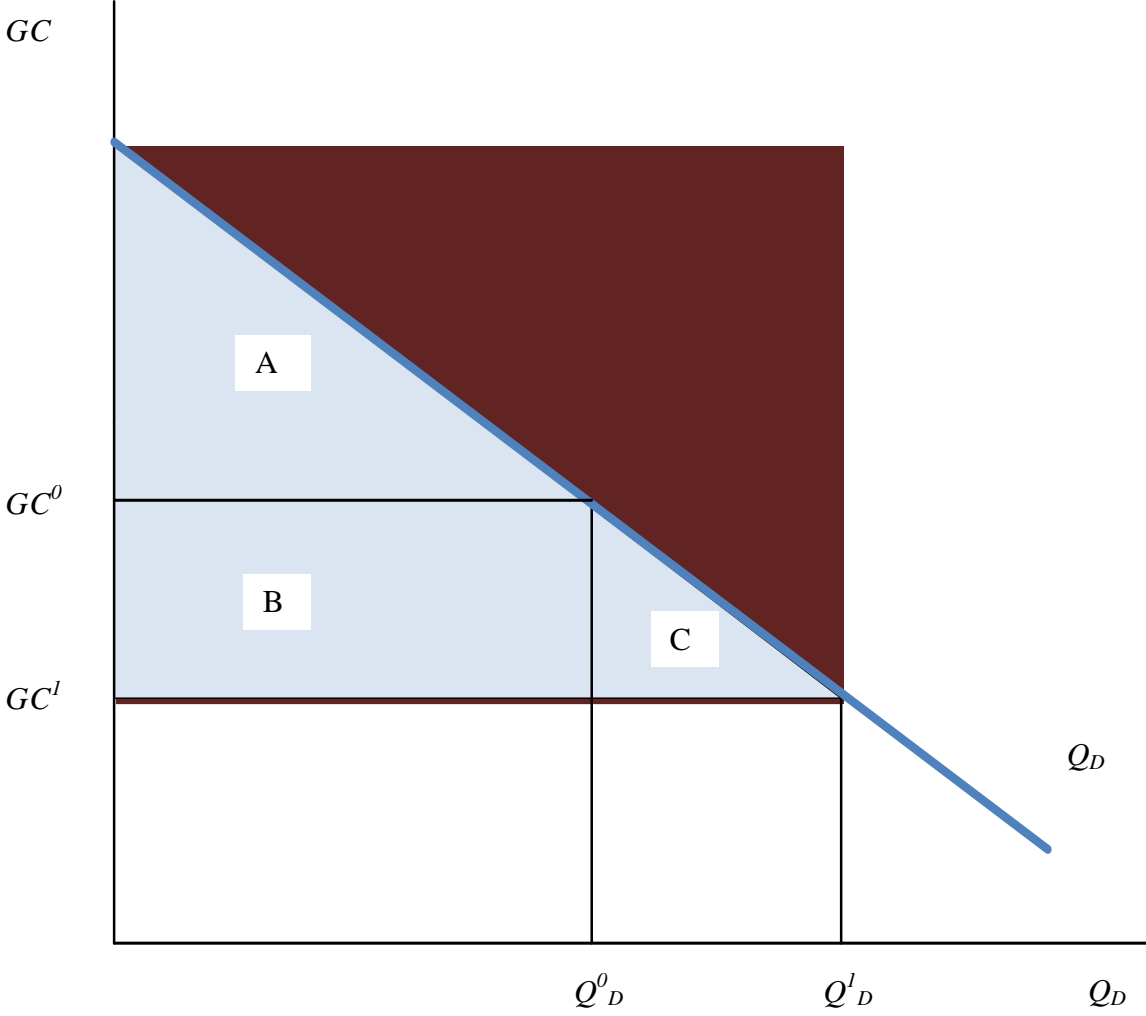
Calculation of user benefits – demand function



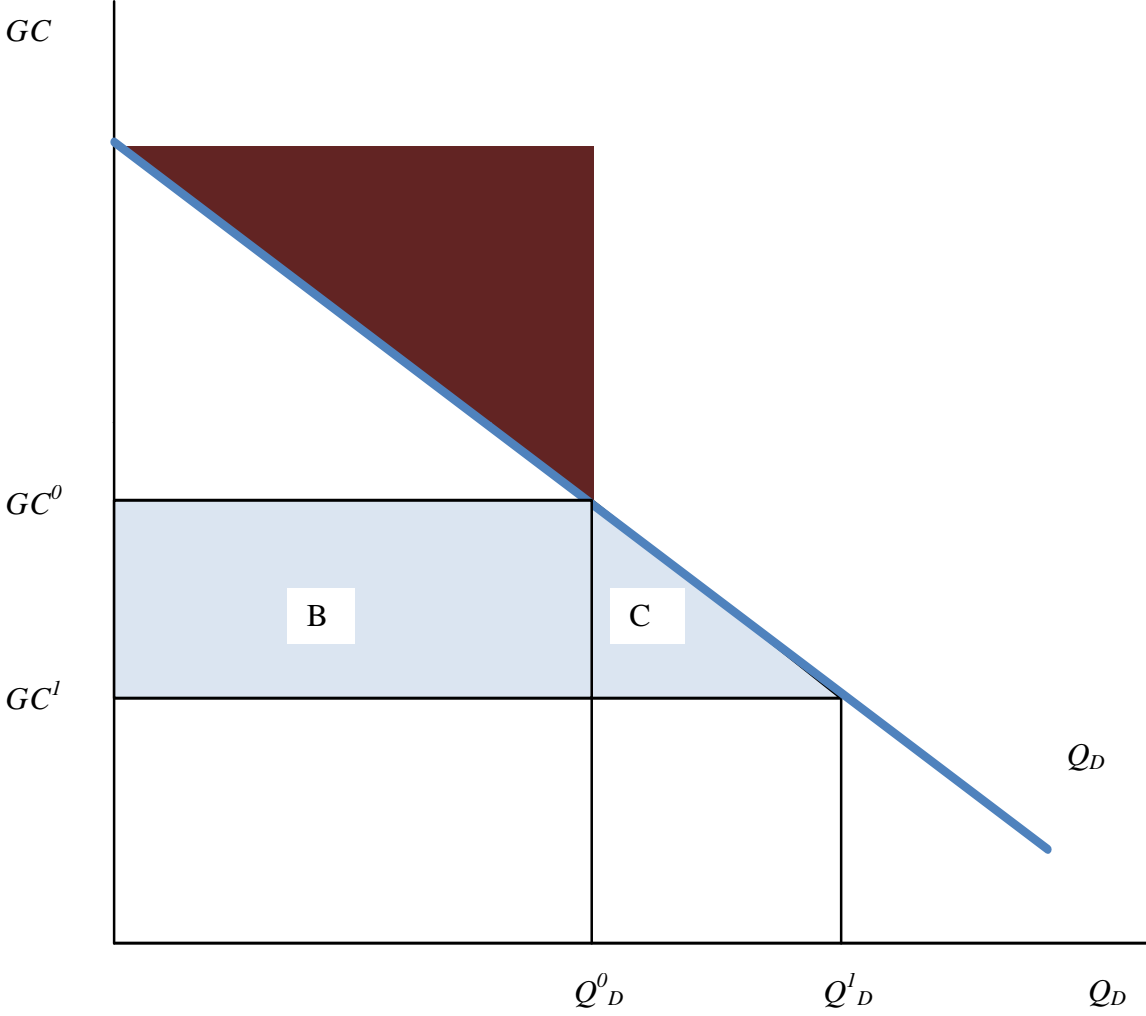
Calculation of user benefits – consumer surplus



Calculation of user benefits – consumer surplus



Calculation of user benefits – Δ consumer surplus



Practical calculation of user benefits

Practical calculations require

- i. Estimates of demand* under the do-minimum and do-something scenarios.
- ii. Estimates of GC* under the do-minimum and do-nothing scenarios.

Assuming a linear demand curve – the ***rule of a half*** can be used to approximate user benefits by

$$\Delta CS \approx \frac{1}{2} (Q_D^1 + Q_D^0) \cdot (GC^0 - GC^1)$$

Separate calculations for time, VOCs, and user charges.

Monetisation of non-monetary elements

- Monetary values are not available for project impacts that are not traded in markets.
- Typically inferred from implicit or surrogate markets using WTP approaches, i.e. amount people are WTP to generate a benefit or avoid a cost (RP / SP methods).
- **Example:** environmental externalities
 - Land value differentials from source of noise.
 - Opportunity cost of production contraction for pollution.
 - Opportunity cost of land in 'second best' employment.
- **Example:** values of time
 - Value of working time inferred from wages (i.e. from labour market)
 - Value of non-work time estimated statistically by looking at trade-offs between time and money (i.e. WTP approach).

UK values of time, 2002 prices and values.

		<i>value (£/hr)</i>
<i>Vehicle</i>	<i>purpose</i>	<i>per occupant</i>
Car	working	21.86
	commuting	4.17
	other	3.68
LGVs	working	8.42
	commuting	4.17
	other	3.68

Extrapolation and discounting

- Extrapolation – prediction of impacts over the lifetime of the project. How will benefits and cost change over time?
- **Discounting principle** - costs (C) and benefits (B) in year t could be funded by investing a smaller amount today, **Present Value** (PV), with regular reinvestment of annual yield.

$$\text{i.e. } C = PV \times (1 + r)^t$$

So we sum the value **today** of all **discounted** costs and benefits

$$PVB = \sum_{t=0}^n \frac{B_t}{(1+s)^t} \qquad PVC = \sum_{t=0}^n \frac{C_t}{(1+s)^t}$$

where s is the discount rate (e.g. interest-inflation).

CBA results

Use results to gives the following summary measures

$$\textit{Net Present value (NPV)} = PVB - PVC$$

$$\textit{Benefit Cost Ratio (BCR)} = PVB / PVC$$

Typical decisions:

- Proceed with project if NPV is +ve.
- Select from alternative projects the one with highest NPV.
- Define a marginal acceptable BCR and accept or reject projects accordingly

Limitations of CBA

- i. **Monetization** – necessarily involves value judgments. These can be contentious and can prejudice the decision maker towards certain project impacts.
- ii. **Sensitivity to input values** – e.g. demand and cost forecasts. Also calculation of NPV and BCR can be highly sensitive to choice of discount rate.
- iii. **Additionality of benefits** – WTP approach creates scope for double counting, particularly regarding ‘transfers’.
- iv. **Magnitude of time savings** – small time saving may have little productive value.
- v. **Coverage** – consumer surplus theory assumes perfect markets and the absence of market failure. Violations of these assumptions create unaccounted benefits / costs.

Wider Economic Impacts (WEIs): agglomeration

- The WTP approach captures most GDP benefits.
- Agglomeration economies are positive externalities derived from the spatial concentration of economic activity
 - **Sources:** knowledge / technology sharing, labour market pooling, specialization, efficient input-output sharing.
- Transport / generalised costs of travel affect agglomeration
 - transport (costs) in part determines economic densities:
accessibility
 - transport constraints can inhibit agglomeration economies
 - new investment changes the *density* or *concentration* of activity (including labour) accessible to firms
- Agglomeration is an externality / market imperfection - as such it is not captured in a standard CBA based on WTP.

Assessment of WEIs in CBA

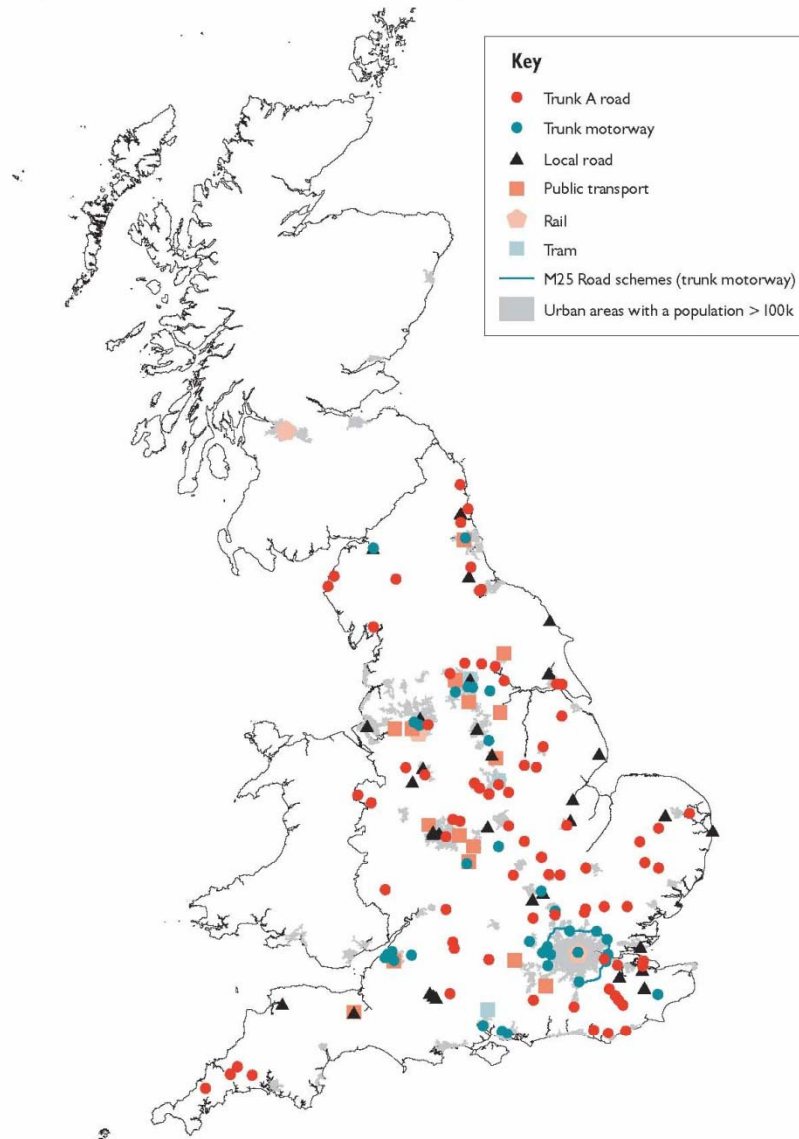
Example: DfT assessed agglomeration for CrossRail, a major mainline rail infrastructure project for central London

Benefits	Welfare (£ million)
Business time savings	4847
Commuting time savings	4152
Leisure time savings	3833
Total user benefits (conventional)	12832
Agglomeration benefits	2440
Total benefits (inc agglom)	15272

Using an agglomeration elasticity of approx. 0.10 → 25% addition to conventional user benefits.

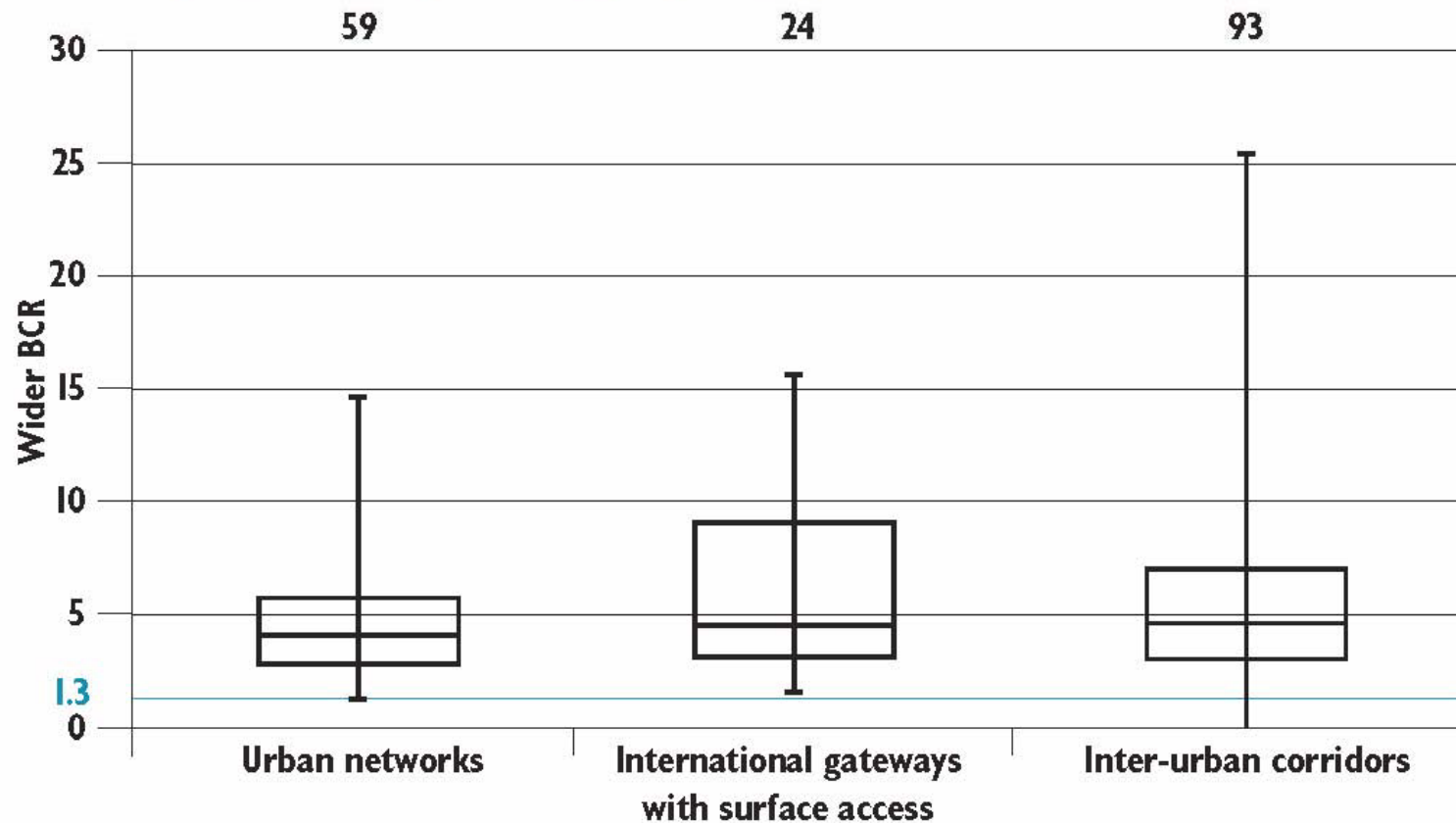
Use of CBA in the UK, Eddington Study

Figure 5.4: Location of interventions in the evidence base



Use of CBA in the UK, Eddington Study

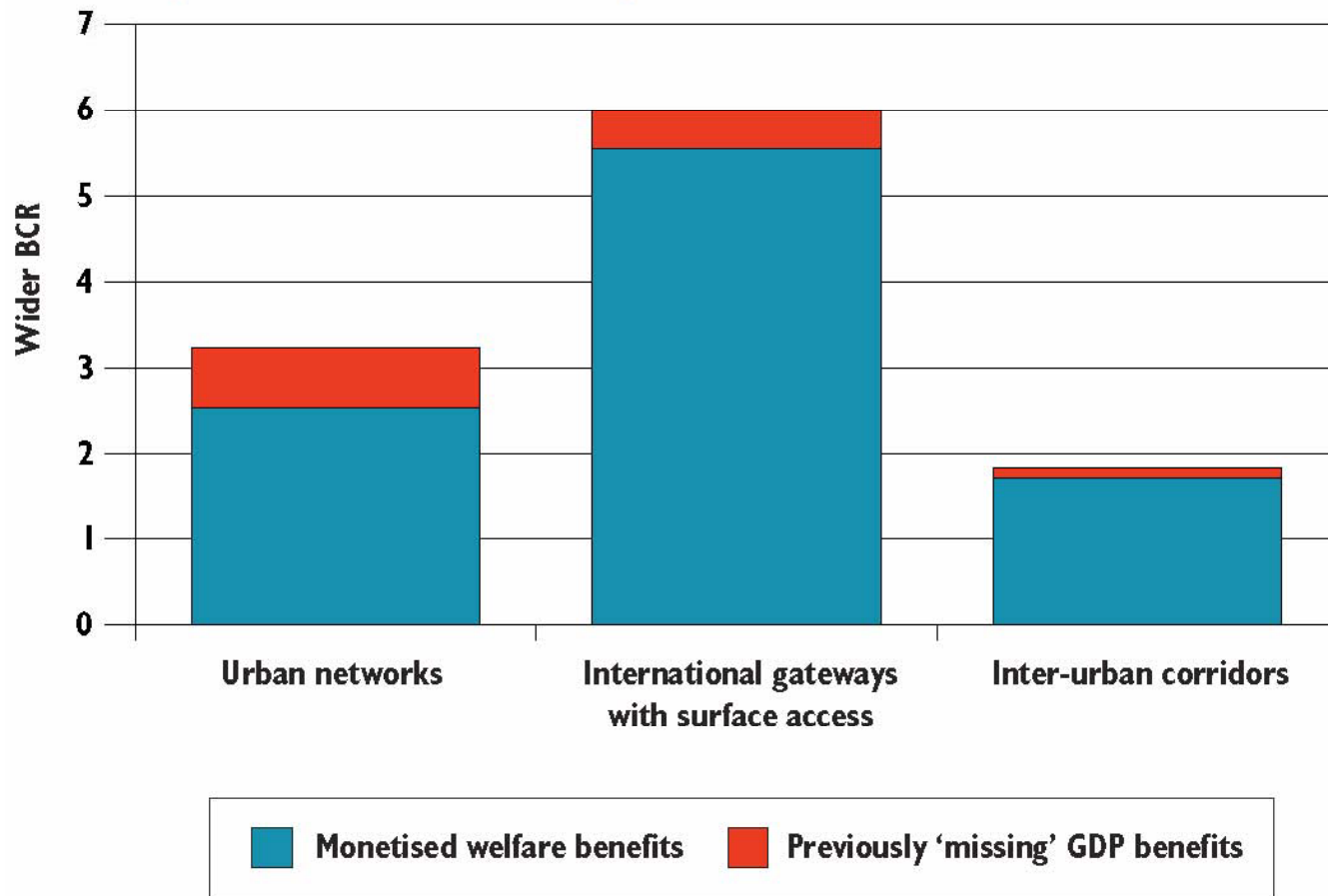
Figure I.3: Distribution of economic returns from government expenditure by strategic priority: wider benefit:cost ratio



Source: DfT.

Use of CBA in the UK, Eddington Study

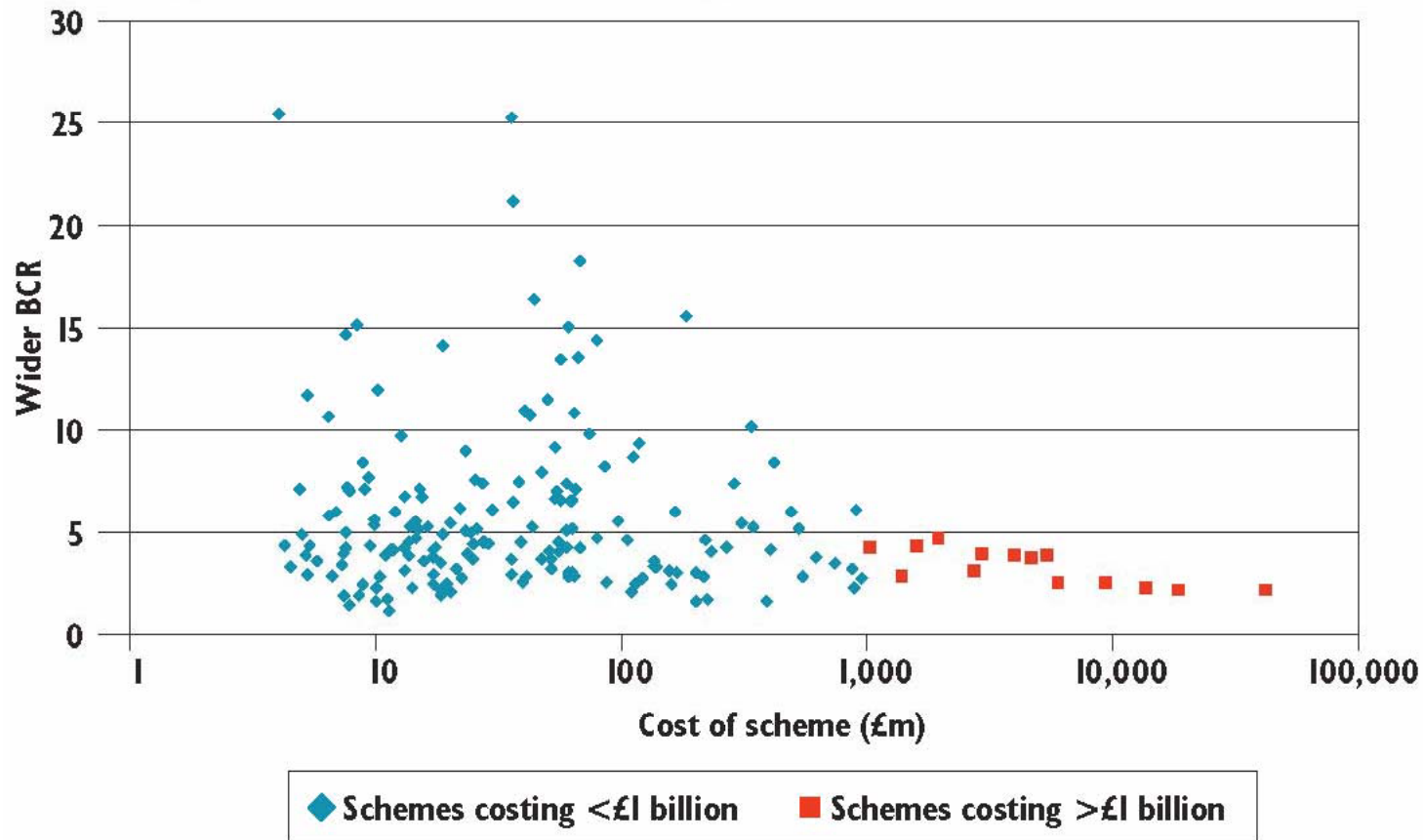
Figure I.5: Average economic returns from government expenditure with GDP impacts added in: wider BCRs



Source: DfT.

Use of CBA in the UK, Eddington Study

Figure I.8: Economic returns of smaller schemes relative to larger schemes (those costing more than £1 billion)^a



^aCosts are in a log scale.

Source: DfT.

References

Mackie P, Graham D and Laird J (2010) *The direct and wider impacts of transport projects – a review*

Mackie P and Nelthorp J (2001) *Cost-benefit analysis in transport*

Mallard G and Glaister S (2008) *Transport Economics*

Layard R and Glaister S (1994) *Cost-benefit analysis*

Eddington R (2006) *The Eddington Transport study, DfT: London.*

Mackie P and Preston J (1998) Twenty-one sources of error and bias in transport project appraisal, *Transport Policy*, 5, 1-7.