UNITED
NATIONS

E

Economic and Social
Council

Distr.
GENERAL

TRANS/WP.5/2002/7
24 June 2002

ENGLISH AND
RUSSIAN ONLY

ECONOMIC COMMISSION FOR EUROPE
INLAND TRANSPORT COMMITTEE

Working Party on Transport Trends and Economics
(Fifteenth session, 2- 4 September 2002,
agenda item 7 (a))

EVALUATION OF INLAND TRANSPORT INFRASTRUCTURE PROJECTS

DRAFT OF THE UNECE SOCIO-ECONOMIC COST BENEFIT ANALYSIS
FOR TRANSPORT INFRASTRUCTURE PROJECT APPRAISAL

Note: Following the request made at the fourteenth session of the Working Party (TRANS/WP.5/30, para. 21), an Informal Meeting involving representatives from Germany, Russian Federation, the European Communities (EC) and the European Investment Bank (EIB) was held on 4 June 2002 in order to review the first draft of the "UNECE Socio-Economic Cost benefit Analysis for Transport Infrastructure Project Appraisal" and examine transport project appraisal methods used by various international organizations.

The revised draft of the document, including comments by the World Bank, European Bank for Reconstruction and Development (EBRD) and participants of the Informal Meeting is reproduced in the attached document for comments and consideration by the Working Party.

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SOCIO-ECONOMIC COST BENEFIT ANALYSIS

FOR TRANSPORT INFRASTRUCTURE PROJECT APPRAISAL

June 2002

Based on
TINA – Transport Infrastructure Needs Assessment

"Socio-Economic Cost Benefit Analysis in the context of project appraisals for developing a Trans-European transport network"
edition issued November 1999: a result of the TINA process,
TINA 015/final1999

First published in English as:

TINA – Transport Infrastructure Needs Assessment
TINA Appraisal Guidance
"Socio-Economic Cost Benefit Analysis in the context of project appraisals for developing a Trans-European transport network in Bulgaria, Cyprus, Czech Republic, Estonia, Hungary, Latvia, Lithuania, Poland, Romania, Slovakia and Slovenia"

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PREAMBLE

[Text to be included]

Geneva, June 2002

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1 RATIONALE OF APPRAISAL

1.1 The social perspective

1.1.1 Transport infrastructure investment affects many parties – local and national Government and the EU, infrastructure providers, transport operators and users, people whose economic, social or environmental quality of life is changed. Often there are winners and losers and the assessment of the project may be different depending upon whose perspective is taken.

1.1.2 The principal perspective of this guidance is a social one, that is one which takes account of all significant effects *whoever is affected*. Relevant considerations include:

- the overall economic, social and environmental effect of the project;
- the pattern of gains and losses;
- the financial viability of the project;
- the practicability of the project and identification of any barriers to implementation.

1.1.3 The focus of this guidance is on the first of these considerations, but with some attention given to the others. The reason for this is that the main test of worth from the perspective of Governments should be a test of overall social value. Some attention will be given to financial viability, but it is expected that this will be the subject of further in-depth analysis by the Banks or other funding agencies if the project passes the tests of social value for money.

1.2 The Framework approach

1.2.1 For the social appraisal of projects, we recommend the use of a Framework approach containing at its core a cost-benefit analysis of those elements which can justifiably be valued in monetary terms, but with additional reporting of environmental impacts, wider economic impacts and other impacts on broader policy issues. The cost-benefit analysis and the broader environmental and policy indicators need to be brought together in a coherent way in order to produce the overall assessment. This is the purpose of the Framework.

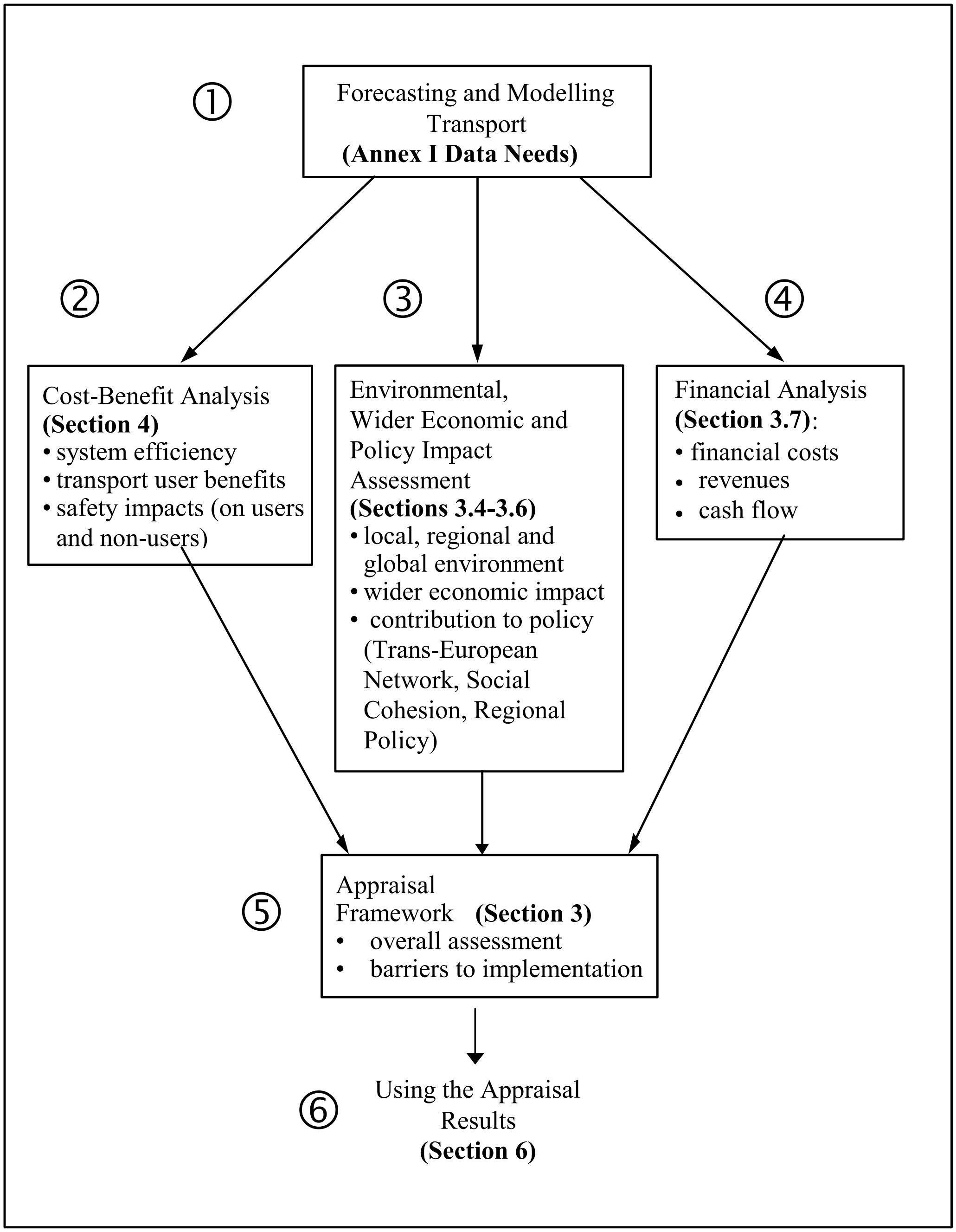
1.2.2 It must be emphasised that the environment and other policy relevant impacts should all be subject to appropriate forms of *analysis*. This analysis should be quantitative where possible. Where that is not possible a qualitative analysis should be performed, based on the judgement of suitably experienced professionals. The basis of the analysis should always be set out as part of the information provided to decision makers.

1.2.3 It is expected that this set of information will form an <u>input to</u> the decision-making process, and not an <u>output from</u> a previous politically irrevocable set of decisions. For this, it is absolutely essential that there exists a range of options to choose from, either within or between transport corridors, or between fundamentally different solutions to the problem.

1.2.4 The task of finding the right balance between the user benefits, environment and other impacts then rests with those responsible for making the decision. The purpose of the appraisal is to provide relevant information as an input to the decision-making process.

1.2.5 A sketch of the appraisal process is shown in Figure 1.1.

Figure 1.1: Overall Schema of the Appraisal Process



Note: bold Section numbers refer to relevant parts of this document.

1.3 Quality of input data

1.3.1 Most of the emphasis of this report is on the economic and social assessment of projects. But it is important to note that appraisal is almost completely dependent on the quality of the base data which feeds it. There have to be reasonable base data on freight and passenger flows, times and costs, and a reasonable basis on which to forecast the key variables such as income growth and planning data which drive traffic growth. Otherwise the appraisal will be unreliable at best and useless at worst.

1.4 Uses and scope of project appraisal

1.4.1 Project appraisal is useful in a range of decision contexts:

(i) whether a project is viable or should be rejected;
(ii) whether a project is the best of a set of mutually exclusive alternatives such as alternative routes, layouts, locations or capacities;
(iii) whether a project is of high or low priority within an overall programme, in other words how a project ranks in relation to other available projects competing for the same funds;
(iv) whether the timing of the project is correct or deferment should be considered.

1.4.2 The uses of the appraisal results are discussed further in Section 4.9.

1.4.3 This guidance is orientated towards projects that are sufficiently well defined to be capable of serious evaluation. The appraisal regime below is conceptually capable of handling projects on all modes of transport, though the guidance will be written in a way that is orientated towards road and rail projects.

2 PROJECT DEFINITION AND SELECTION

2.1 Project definition

2.1.1 There are three main areas to consider prior to starting project appraisal itself. First, it is necessary to be sure that the required data is available adequately to define the do-minimum situation (see Box 2.1) and to permit the modelling and forecasting of future traffic flows. This data is discussed in Annex II Data Needs. Note that there should be consistency between the envisaged level of sophistication in the modelling and the data to support it. It is advisable to think such questions through at the outset of the analysis, in order to avoid having to respond to problems once the modelling is under way.

Box 2.1: Do-minimum and do-something scenarios

The appraisal compares a minimum of two alternative scenarios, or states of the world, and gives an indication of the net social benefit of one relative to the other. The scenarios being compared are:

a realistic **do-minimum scenario** - in which the transport network is as it would be if the project in question was not implemented. Clear definition of the do-minimum scenario is critical to ensure that all projects which form alternative schemes for a particular area are compared against a common base. The do-minimum scenario is meant to include a realistic level of maintenance and a minimum amount of minor improvements where absolutely necessary, to avoid the transport network deteriorating - a pure do-nothing scenario would lead to unacceptable transport conditions so is not useful as a base for appraisal.

one or more **do-something scenarios** - in which the transport projects (or project options) are included in the transport network.

2.1.2 Secondly, it is necessary to ensure that the parameters and values within the cost-benefit analysis, such as the discount rate, values of time and values for accident savings, are already available in a form consistent with the requirements of Annex VI, or that the facility to calculate them exists. These parameters and values are set out in Box VI.1 and Box V.2.

2.1.3 Thirdly, it is important to give attention to the individual projects themselves:

i) Are they clearly defined? For example, what are their objectives, what are the costs, who would be responsible for implementation and what are the details of location and design in relation to the wider transport network? For the EU accession countries the ISPA Application for Assistance [1/] should be regarded as the benchmark for a full project definition. For any projects lacking a clear definition, the ISPA questionnaire will serve as a guide to preparing one [2/].

[1/] ISPA= Instrument for Structural Pre-accession Aid, Council regulation (EC) No 1267/1999 of 21 June 1999 establishing an Instrument for Structural Policies for Pre-accession

[2/] For details regarding the project definition and the complete description of elements of the project please refer to: Commission of the European Communities, Application for Assistance Under the ISPA, Financial instrument, Transport, and Application for Assistance Under the ISPA, Financial instrument, Technical Assistance.

ii) Does the project include all essential sub-projects, without which the main project would not work, or would be significantly diminished in performance? In the ISPA questionnaire, the term 'measure' is used to describe any of the following types of proposals:

- a single project;
- a technically and financially independent stage within a project; or
- an inter-dependent group of projects.

If the measure being put forward for appraisal is actually dependent upon other projects (or project stages) outside its own scope, there is a risk that the expected benefits will not be achieved. Therefore it is important that the measure includes all essential projects and project stages. Although in this guidance we use the term 'project', rather than 'measure', the message is unchanged - projects submitted for appraisal should be complete in themselves, and going ahead should be enough to secure the stated benefits.

iii) A further issue in initial project definition is to ensure that the most appropriate scale, design and timing are chosen. Project definition is a dynamic process: if at first a project does not appear viable it may be possible to make it so by going back to the definition and considering making changes. For example, given that investment funds are often in short supply, it is worth asking whether a lower cost, more basic specification might not deliver a large proportion of the benefits expected from a more ambitious scheme, but also leave resources available to tackle problems on other parts of the network. Alternatively, it may be worth considering staged implementation, with, for example, a two-lane being built first but with the possibility of expansion to a four-lane road at a later date secured by choosing an appropriate specification for the overbridges, junction layouts, etc. A full appraisal of every alternative project definition would be prohibitively expensive. The use of appropriate informal assessment and professional judgement during the project definition stage should help to ensure that the option finally evaluated is as close as possible to the optimal specification for the project.

iv) Many projects that will be considered within current funding programmes will have been identified previously and carefully specified for analysis. Nonetheless it is important, prior to appraisal, to review each one's specification and to ask whether it has been up-dated to take account of recent developments.

2.2 Procedures for screening projects

2.2.1 It is common for countries to have a large number of schemes in mind that they would like to see built, and which may well be desirable in socio-economic terms. If, however, the investment capital to build them is unavailable and not likely to be available in the immediate future, there is little to be said for using scarce resources to put them through the appraisal process. It is therefore better to do some pre-screening of the list of possibilities, so that only the most promising schemes are evaluated.

2.2.2 Projects submitted for financing to IFIs and donor countries should be the result of a screening process within the country. The following is a simple checklist of points to bear in mind when screening projects for submission:

- ensure that all individual projects are adequately defined (Para 2.1.3)
- identify in broad terms, the performance of the project on a small number of key indicators (for example, time and cost savings; environmental improvement; wider economic impact; safety; capital costs; operating costs.) and use this as a rough basis for screening or ranking
- identify whether benefits are dependent on neighbouring projects (in the same corridor) also being implemented
- assess whether there are barriers to implementation, for example physical or political barriers.

2.2.3. In circumstances where there are clearly many more projects than there are opportunities for investment, some process broadly of this type should help ensure that appraisal resources are properly focused on projects that stand a chance of implementation.

3 THE APPRAISAL FRAMEWORK

3.1 Aims

3.1.1 Transport infrastructure projects can be expected to have consequences for the national (and possibly international) economies, for the regional and global environment, and potentially for other aspects of society in the countries concerned. The principal aim of the appraisal framework is to *capture* the most significant of these effects and to *report* them in a form that is consistent from one project to the next. In this way, investment decisions can be influenced by an understanding of the longer-term social consequences of alternative courses of action.

3.1.2 In a world of limited budgets, however, this is not sufficient to justify a transport investment project – it must be consistent with the fiscal and financial capability of the implementing agency. The secondary aim of the appraisal framework is therefore to report clearly on the financial implications of the project from the viewpoint of this agency.

3.1.3 The third and final aim of the appraisal framework is to draw attention to any practical barriers to implementation which exist, over and above the issues - such as severe environmental damage or financial non-viability - which arise naturally elsewhere in the framework.

3.2 Overview of the Framework

3.2.1 These aims can be met by a framework which allows five key groups of effects to be reported, plus a sixth category of *practical barriers to implementation*. The five are the groups of effects introduced in the 'overall schema of the appraisal process' in Section 1 (Figure 1.1), namely:

- effects on transport user benefits, system efficiency and safety;
- environmental impacts;
- wider economic impacts;
- policy impacts beyond the transport system; and
- financial implications for implementing agency (or agencies).

3.2.2 In each case the *effect (or impact)* is defined as the difference between a particular indicator in the do-something scenario (with the project) and the do-minimum scenario (without the project). A full definition of the do-something and do-minimum scenarios is given in Box 2.1. Different analytical methods are required for each group of effects - these methods are outlined, with appropriate references, in Sections 3.3 to 3.7.

3.2.3 The Appraisal Framework brings together all the analysis in the form of a summary table, supported by a series of more detailed tables. An example of the summary table is shown in Table 3.1. The indicators chosen to represent the project effects may vary according to the requirements of particular funding bodies, however, it is essential that the same set of indicators be provided for all the projects which are being compared directly with one another. Examples of the more detailed tables that should be provided to support the summary, including suggested indicators for each of the groups of effects, are given in Annex V.

Table 3.1: Appraisal Framework: Summary

Project Definition	
Nature of the problem; objectives of the project; brief project description.	
Alternatives Considered	
Brief description; reasons for rejection.	
Effects	**Indicators**
Transport user benefits system efficiency and safety	Transport cost-benefit analysis (CBA) results†
Other transport system efficiencies	Transport network, pricing, interoperability
Environmental impact	Local impacts Regional impacts Global impacts
Wider economic impact	Impact on regional employment and production††
Other policy impacts beyond the transport system	Record of relevant policies (land use; private participation, social policy; …) Consistent/in conflict
Financial viability	Cash flow over 10 years
Constraints	**Indicators**
Other practical barriers to implementation	Case specific

Note: † for detail see Section 4 and Annex III.
†† for detail see Annex IV

3.2.4 All parts of the framework should be completed for all projects. The guidance in this document can, however, be regarded as 'modular':

- sub-Section 3.3 introduces the transport cost-benefit analysis;

- sub-Sections 3.4 to 3.7 outline the principles of appraisal for the environment, wider economy, policy and financial implications. However, donor countries, the individual IFIs, and EU funds have their own detailed requirements in these areas which should be considered carefully before deciding on the precise method of analysis and form of reporting for a particular pool of projects. Accordingly, we limit ourselves to an outline of what is required on these impacts.

- Section 4 and Annex III covers the transport cost-benefit analysis in greater depth, including transport user benefits, system efficiency and safety, and noting where information relevant to the financial analysis is generated.

- Section 5 outlines how uncertainty about future economic scenarios should be treated.

- Section 6 concludes by reviewing the ways in which the appraisal results can be applied in choosing between alternatives, prioritisation and ranking.

3.3 Effects on transport user benefits, transport system efficiency and safety [3/]

3.3.1 Some of the most direct effects of the transport infrastructure projects will be on agents who use (or will use) the transport system and transport providers. The cost and time expended by transport users in getting from place to place will be reduced, both for personal travel and freight movement. This fall in costs is likely to lead to a range of user responses – changes in route, mode and destination choices, and newly generated trips. The correct evaluation of these changes in demand is vital to the appraisal and is discussed in Section 4 below.

3.3.2 Impacts on transport providers are also directly relevant, in terms of capital costs, operating costs and revenues – for infrastructure, vehicles and service operations.

3.3.3 Impact on transport system efficiency may also be arrived at through:

(i) the establishment of adequate transport network policies (e.g. Trans European Network policy), which centre on projects forming a strategic link in a wider network, e.g. bringing a part of the network up to a common standard, or establishing a border crossing in the international network;

(ii) insurance of interoperability between the individual modal networks (in the context of railway transport, for example, according to the Directive 2001/16/EC of the European Parliament and of the Council interoperability is “the ability of the trans-European conventional rail system to allow the safe and uninterrupted movement of trains which accomplish the required levels of performance for these lines”;

3.3.4 At the same time, the transport system has associated with it a certain level of accidents, which individual projects may serve to increase or reduce. Both transport efficiency effects and safety effects are expected to be included within a *social cost-benefit analysis (CBA)*. Supporting documents on the assessment of safety include those by the CEC Common Market Expert Group (1994) and EVA Consortium (1991).

3.4 Environmental impacts

3.4.1 Transport system changes, and the resulting changes in transport use, affect not only participants within the transport system itself, but also those who are exposed to the system or its emissions without being directly involved. Environmental impacts occur at a *local level*, for

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[3/] All of the items referred to in 3.3 are described in more depth in section 4.

example changes in exposure to noise and vibration, or to airborne pollutants, or visual intrusion; at a *regional level*, for example, acidification as a result of air pollution; and at a *global level*, through climate change.

3.4.2 As a general principle, projects should be designed so that any severe or dangerous localised effects are offset by mitigating measures of some form. It is essential that the cost of these measures is included in the investment cost of the project. The World Bank, for example, has specific requirements concerning internalisation of environmental costs (that is, ensuring that they are borne by the promoters or users of the project rather than third parties) including resettlement of displaced population. Any remaining localised effects need to be reported, however, and the appraisal framework allows for this.

3.4.3 Provision for Strategic Environmental Assessment (SEA) for infrastructure projects in Europe was made by Directives 85/337 and 97/11 of the European Commission (CEC, 1985; CEC, 1997). Detailed practical guidelines on how to conduct an SEA are given in manuals available through the EU (EU 1999, EU 2001). Promoters of transport infrastructure projects are advised to consult the funding bodies they are approaching to establish whether they have any specific requirements - this is a rapidly developing area of appraisal.

3.4.4 As a simple guideline, a checklist of environmental impacts to be considered in a comprehensive SEA is given in Table 3.2. Effects during construction should be clearly distinguished from effects during operation. Useful additional guidance on assessment and appropriate indicators may be found in Danish Road Directorate (1994), Friedrich et al (1998), Bickel et al (1997), CEC (1985).

Table 3.2: Checklist of environmental impacts

Impact Group	**Impact**
Local	Noise and vibration
	Air pollution
	Ecology (habitats/species/soil/vegetation)
	Heritage assets
	Landscape and townscape
	Severance
Regional	Air pollution
Global	Greenhouse gas emissions

3.5 Wider Economic Impacts

3.5.1 Beyond the transport CBA outlined in Section 3.3, the Framework includes a range of effects that can be considered ‘non-transport effects’, in the sense that they do not appear as changes in prices or quantities in the transport sector. Instead, they appear elsewhere in the economy, the environment or society. The environmental effects set out in Section 3.4 are examples of this. The policy impacts on land-use, social policy, transport policy and other policy issues in Section 3.6 are further examples. In this Section, we are concerned with a specific set of ‘non-transport effects’ which are typically labelled ‘wider economic impacts’.

3.5.2 Transport CBA, when carried out as described in Section 4, includes the benefits to transport users – both passenger and freight – when networks are upgraded. This includes benefits to new users as well as existing users. These benefits are measured directly in the transport sector, as the change in customer surplus (see Section 4).

3.5.3 Under certain conditions, transport infrastructure may lead to additional economic benefits – from a social viewpoint. These conditions are explored in recent and current economic research (SACTRA, 1999; Mackie et al, 2001). The issues and techniques relevant to Wider Economic Impacts are discussed further in Annex IV. The Wider Economic Impacts heading provides space to report on the findings of such an analysis. The key indicators which may be reported within the Framework – if available – are predicted change in regional production and regional employment *for specified regions.*

3.5.4 However, analysts need to be aware that the IFIs require first and foremost a Transport CBA as described in Section 4. When allocating resources within the appraisal budget, a much greater share should be allocated to Transport CBA than to Wider Economic Impacts. Also, great care needs to be taken to avoid double counting, - that is to say, counting the same benefit both as a direct transport user benefit and as a wider economic impact.

3.6 Other Policy impacts

3.6.1 The next group of effects are the impacts on other public policies beyond the transport system. Governments (central and regional) typically invest in transport not only because of the expected national gain in economic efficiency and mobility, but because the investment is expected to have positive socio-economic effects on other areas of policy interest. The potential impacts on output and employment have already been assessed under the heading Wider Economic Impacts.

3.6.2 Other specific policies that should be examined are :

- land use policies - does the project support or conflict with plans to use particular areas for industry, agriculture, residential/housing, national parks/nature reserves. For example, if a rail improvement project included new stations in areas zoned for agriculture rather than residential/commercial development, this would amount to a conflict with land use policy and should be noted as such in the Appraisal report;

- transport network policies (see also 3.3.3);

- social policy issues and social cohesion;

- pricing policies;

- private participation;

- international nature of the project.

3.6.3 The appraisal framework includes a space to report on the consistency - or conflict - between the transport project and the relevant policies of governments and funding bodies affecting the area and mode in question. The reader should be aware that different funding bodies have different policy contexts, and these should be taken into account when reporting on the degree of consistency or conflict.

3.7 Financial implications

3.7.1 Within the overall appraisal framework, a financial appraisal is required for the following reasons:

- to ensure that projects are consistent with the fiscal and financial capabilities of the implementing agency (or agencies);
- to ensure that the financial revenues and costs for the implementing agency are based on estimates of demand and prices/tolls which are consistent with the demand evidence used in the cost-benefit analysis, including evidence of users willingness to pay. Specifically it is not satisfactory to carry out an investment appraisal of any priced facility without explicit consideration of the relationships between prices, demand, revenues and user benefits.

3.7.2. In order to aid consistency, the financial appraisal should take the form of various pieces of data extracted from the overall cost-benefit analysis. These are:

- financial investment costs;
- financial infrastructure maintenance and operating costs;
- vehicle operating costs (VOCs) met by operators (VOCs met by users - for example, car and own-account freight VOCs are not included here);
- revenues.

3.7.3 The financial analysis is concerned with the impact of these items on transport operators, infrastructure providers and government transport and finance ministries, in cash flow terms. Table 3.3 outlines an appropriate form of presentation. Receipts are the sum of revenues; payments are the sum of investment costs, infrastructure maintenance and operating costs and VOCs. It will usually be necessary to prepare a cash flow analysis for the do-minimum scenario and another for the do-something scenario. The impact of the project will be the difference between the two.

Table 3.3: Simple cash flow analysis for one organisation in one scenario

Year	Receipts, euro	Payments, euro	Net Cash Flow, euro

1			
2			
3			
4			
5			
6			
7			
8			
9			
10			

3.7.4 Whereas CBA values should be on a resource cost basis (see Section 4.4 below) the financial appraisal values should be on a commercial basis at market prices. That is, financial appraisal should include any indirect taxes and subsidies paid/received by the agency. This is because the financial appraisal should give the best estimate of the financial flow for the implementing agency or agencies.

3.7.5 Important questions to attempt to answer include:

- is the project financially self-sustaining over its expected life?
- are the financial assumptions and forecasts consistent with the cost-benefit analysis? For example, will the users be willing to pay the tolls or fares assumed in the financial appraisal?
- how sensitive are the financial results to the underlying economic assumptions?
- in a project which is worthwhile overall are there financial problems for certain institutions (e.g. the railway operators) and how are these to be overcome?

4 COST-BENEFIT ANALYSIS

4.1 Principles of Social Cost-Benefit Analysis

4.1.1 Cost-benefit analysis (CBA) has its foundations in the theoretical framework of microeconomics and in the theory of social choice. It is an application of these theories to the practical problems of public sector decision-making, not just in transport, but in health, power generation and environmental protection, amongst others. Readers requiring knowledge of the theoretical foundations of CBA are referred to one of the cost-benefit reference books listed in the References section, for example, Pearce and Nash, 1981, Chapters 2 and 11). Some of the key principles of transport CBA can, however, be summarised as a general process as follows:

- costs and benefits to all affected groups should be considered;
- some effects may be transfers from one group to another and these may cancel out in the overall analysis, but distributional impact is important;
- the overall social impact is calculated simply by adding the impact on individuals;

- costs and benefits in the future are relevant, and forecasts of the future should always be on the basis of expected behaviour (this is particularly important for the demand forecasting stage of the appraisal);
- the evaluation starting point is individuals' willingness to pay for benefits based on studies of the value of time and safety; although values are sometimes adjusted for equity considerations;
- as far as possible, items of costs and benefits should be valued in commensurate terms;
- the numeraire is money (although in principle, other numeraires could be used instead);
- explicit procedures are needed for valuing costs and benefits accruing at different points in time - that is, discounting and growth rates for values over time.

4.1.2 The CBA method outlined below is a based on long-standing techniques used in the European Union, including during periods when transport infrastructure was much less developed than it is today. Special circumstances of transition economies have required some modifications, in particular to allow for limited availability of data on transport use and uncertainty arising from economic volatility. These concerns have led to a CBA method being recommended which requires relatively little modelled data, although the principle that the quality of the results is very dependent on the quality of the data inputs still applies. Transition specific issues have also led to a method where sensitivity of the results to assumptions about economic growth is tested and reported prominently within the framework.

4.2 The CBA Process

4.2.1 Figure 4.1 summarises the steps involved in carrying out the cost-benefit analysis for transport infrastructure projects. It will be clear from this that the CBA is a relatively complex exercise requiring a range of inputs and comprising a number of distinct stages. In Sections 4.3 to 4.10 an outline is given of the appraisal requirements at each of these stages, with references to sources of more detailed guidance in the cost-benefit literature where appropriate.

Forecasting and modelling

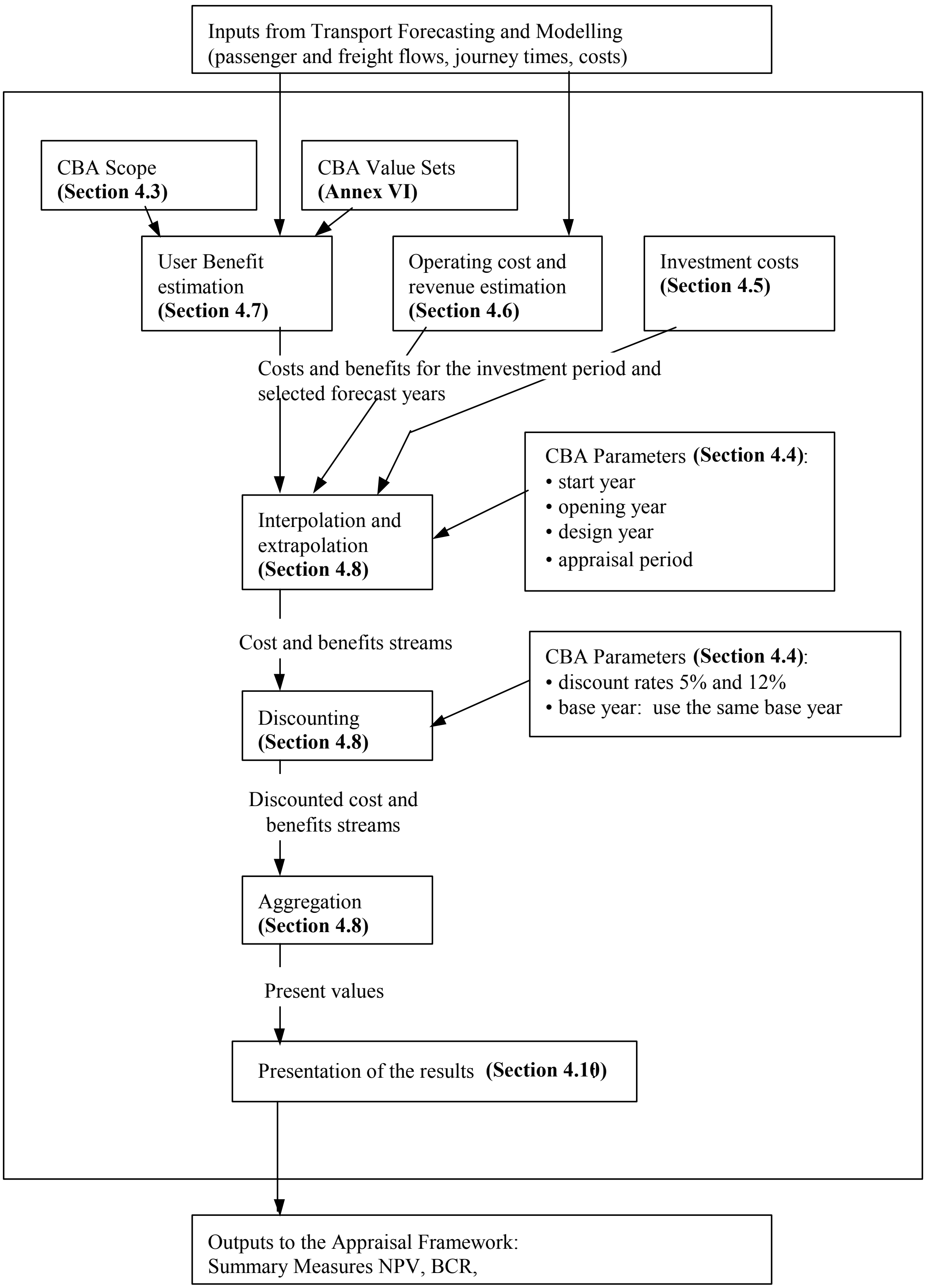
4.2.2 Note that there are inputs to the CBA from the forecasting and modelling exercise, in the form of flows, journey times and costs in the transport system. For example, in the TINA countries, traffic forecasts on the ten 'Helsinki' transport corridors are available in the NEA/INRETS/IWW report (1999). It is recommended to establish a similar report on traffic forecasts on major Euro-Asian transport links in CIS countries. Demand growth across the transport modes should be consistent with the corridor-level growth projected by these reports. For traffic between particular origins and destinations, further analysis will be necessary at a more detailed level. Data needs for transport CBA are described in Annex II of this guidance.

4.2.3 For project appraisal, it is crucial to distinguish between sources of traffic growth which are exogenous, or external to the project (such as the growth of GDP, or changes in fuel prices) and growth which is endogenous, or induced by the project. It is strongly recommended that this induced traffic is explicitly modelled by means of traffic elasticities to journey time or price, and that the transport benefits should include the benefits to induced traffic. This is discussed in more detail in Annex III. The sources of exogenous growth such as GDP and fuel price trends are subject to uncertainty, and therefore traffic growth over time may best be handled by considering a range of scenarios. It is important that the network capacity should be capable of handling the forecast volume of traffic: where this is not the case, the effect of capacity limits on delays and service quality will be required.

Appraisal outputs

4.2.4 Note also that the outputs from the CBA (at the foot of Figure 4.1) feed into the Appraisal Framework, in the form of summary CBA results. Outputs broken down by group in society (that is, transport users, transport operators and government) and outputs broken down by mode of transport, should be reported in a separate table (for example, see Annex V Table V.4).

Figure 4.1: The CBA Process



4.3 Establishing the scope of the CBA

4.3.1 At the start of the CBA process, a view will need to be taken on the scope of the analysis, that is, what to include and what to rule out as being irrelevant or insignificant. In particular:

- i) which modes of transport should be included?
- ii) what are the boundaries of the Study Area?
- iii) what are the specific impacts to which CBA should be applied?

4.3.2 Setting the scope of the CBA too widely will result in data being gathered and analysis undertaken which is of no use in calculating the total impact of the project. Setting the scope too narrowly could mean that significant impacts are left out. Therefore, it will be helpful for the quality and cost-effectiveness of the CBA, to consider these issues before proceeding. The guiding principle should be: all significant effects should be covered; effects which are insignificant or nil in total should be ruled out in advance if possible. Consideration needs to be given to the significance of effects over the life of the project (see Section 4.4)

Modes of transport

4.3.3 Modes affected may include not only the mode(s) improved by the project, but other competing modes in the same corridor from which demand may be abstracted, **and** modes to which the project will feed additional demand (for example, rail links to a new airport). Once relevant modes have been identified, appropriate data should be gathered (see Annex II). This data will typically include current flows on the competing/complementary modes and any available evidence on how they would respond to the project.

4.3.4 Modes that should be considered include the following.

Table 4.1: Modes covered by Transport CBA

Infrastructure type	**Modes**
Road	Car; Motorcycle; Bus and coach; Road freight (van/lorry/truck)
Rail	Passenger train; Rail freight
Air	Air passenger; Air freight
Navigation (inland/seaborne)	Passenger ferry / riverboat; Waterborne freight

4.3.5 The ‘slow modes’ (pedestrians and cycles in particular) should be considered carefully when appraising transport infrastructure projects. In theory, it would be desirable to bring them into the CBA, so that the treatment was consistent with the motorised modes, however, techniques are not yet sufficiently advanced to do so in most cases (although the World Bank has in a very few cases accepted analysis of this type). Therefore they are excluded from the cost-benefit analysis. Nevertheless, effects on local access across new/improved infrastructure must be reported under an appropriate heading (for example, ‘severance’ in the environmental impact assessment (Section

3.4). Problems with provision for pedestrian/cycle movement along the routes provided with new infrastructure should also be identified and reported within the environmental assessment. Where possible, these problems should be addressed by revisions to the project design, incorporating *mitigating measures.* The investment costs should also be reviewed, followed by a re-appraisal. Any remaining problems must be clearly identified in the appraisal reporting tables.

Study area

4.3.6 The study area should be the smallest area consistent obtaining reliable results. That is, it should be large enough to include all the significant effects of the project but no larger than that, to avoid wasting appraisal resources in areas where there will be no effect. The study area should aim to put the project in the context of the local road or rail (and possibly multi-modal) network.

4.3.7 The simplest hypothetical case would be a project which improved particular links in, say, the rail network without inducing any changes in the transport flows anywhere else in the network. Such a project could be subjected to CBA using data only for the flows on the routes forming part of the project, since no significant effects would be expected elsewhere. In reality, most projects will induce various changes on adjacent routes or links:

- routes or links feeding traffic onto the project may experience demand growth relative to the do-minimum;
- routes or links bypassed by the project may experience demand reduction;
- routes or links on other modes may also be affected.

4.3.8 The aim of the study area definition should be to include all parts of the transport network which are likely to experience significant changes in flow, cost or time as a result of the project. This includes links on the road network; stations and links on the rail network; airports; ports and waterways. For all these links, input data will be required, and the results of the CBA will apply to this area. The study area should be defined in the form of a map and included in the appraisal outputs. Further guidance is given in Annex II Data Needs.

4.3.9 In situations where networks are being developed, there are issues of interdependence between different projects within the overall strategy. Where projects are in series, they feed traffic to each other, so that the benefit of the whole network strategy is greater than the benefit of each individual section standing alone. Where more unusually, projects are in parallel (e.g. rail and road improvements in the same corridor), the opposite will be the case In these cases, in principle, appraisal requires:

– an assessment of the overall strategy

– an assessment of individual elements within the strategy

(a) assuming that they are stand-alone projects

(b) assuming that they are a part of the strategy (the so-called last link in the network method).

Then a project which passes test (a) is robust and should proceed. A project which fails test (b) is unsound and should not proceed. A project which passes test (b) but fails test (a) may proceed as part of an overall strategy.

4.3.10 The recommendations in paras. 4.3.6-8 above apply to this regime of testing. An implication of this is that there may be a need for detailed modelling of the study area or corridor where the project is located, with a coarser strategic model of the wider region, enabling some assessment of the effects on the system as a whole.

4.3.11 Where many different elements are involved in developing a network, the number of combinations can become too high for an exhaustive approach. Therefore we recommend as a practical minimum that the following scenarios must be considered.

- a do-minimum baseline of the existing network;
- a do-something scenario in which the project is evaluated against the do-minimum on a stand-alone basis;
- a do-something scenario in which the project is evaluated as part of a wider strategy against the do-minimum baseline.

Impacts to be included

4.3.12 The aim of the CBA is to measure the change in social surplus created by the project, which is the sum of the changes in producer surplus and consumer surplus (see Section 4.7). This is achieved by measuring the benefits, revenues and costs to transport operators and users. To achieve this, the CBA should address the following set of impacts (Table 4.2) and the disaggregated CBA results (for example Table V.4) should report each impact separately.

Table 4.2: Cost benefit analysis: set of impacts

Investment Cost
Changes in:
Infrastructure and System Maintenance and Operating Costs
Vehicle Operating Costs
Journey Times
Safety
User Charges
Operator Revenues

4.3.13 However, there may be some slight differences between projects as follows:

- projects which involve improvements to road systems without road tolls and which are not expected to affect flows, costs or travel times on other modes, will have no impact on User Charges or Operator Revenues.

... and between the effects of projects on different modes of transport as follows:

- car users and own-account freight users on road/rail/air/water, must pay their own vehicle operating costs (VOCs) whereas on other modes, users pay a charge to the operator in return for a complete transport service and the operator meets the VOCs. This difference in the attribution of impacts to groups also has implications for the way in which the costs/benefits are calculated (see Sections 4.6 and 4.7).

These differences will be reflected in the appraisal results.

Domestic and International traffic

4.3.14 Both domestic and international traffic should be included in the appraisal, and treated equally, but should be separately identified in the input data and the CBA results to show the contribution of the project to the facilitation of transport and trade across borders. Any waiting time or delay costs at borders should be modelled explicitly

4.3.15 Domestic traffic is defined as consisting of trips whose origin and destination both lie within the same country. All other traffic is defined as international traffic for appraisal purposes.

4.4 Parameters for the CBA

4.4.1 In order to carry out the CBA calculations, values for certain general parameters need to be known. Some of these need to be common across all appraisals; others should be common within each particular pool of projects being compared (for example, rail infrastructure projects in Slovakia; or road infrastructure projects in Cyprus). Table 4.3 sets out what is expected.

Table 4.3: CBA parameter values

Parameter	**Value**

Discount rates	5% and 12% per annum for all projects
Project start year	project specific
Investment period	project specific
Project opening year	project specific
Design Year or Reference Year	10th full year of operation
Operating period	30 years for all projects
Appraisal period	variable, given Investment Period and Operating Period (by definition, the Appraisal Period runs from the Project Start Year to the last year of the Operating Period)

4.4.2 The CBA is to be carried out on a real terms basis, that is to say with all values throughout the appraisal period being based to a convenient recent year such as year 2000 prices and values. So the CBA is conducted in a world free of general inflation. However, if the prices of specific inputs or outputs are predicted to change relative to other prices these real price effects should be allowed for. Commonly, future energy prices require special treatment in this respect.

4.4.3 The internationally recognised convention for transport CBA is that appraisals are carried out on a resource cost basis. That is, all inputs and outputs are valued net of indirect taxes. Where market prices diverge significantly from real resource costs (e.g. due to heavy indirect taxation on fuel), case is needed to respect this convention correctly.

4.4.4 In countries with particularly volatile currencies, it may be appropriate to conduct the entire appraisal in hard currency terms (e.g. euros or $US). In any case, great care is required to ensure the realism of the exchange rates used in the appraisal.

4.4.5 The discount rates of 5 and 12 per cent are based on discussions between the EU and the International Financial Institutions about appropriate discount rates for infrastructure projects. The 12 per cent figure is regarded as a minimum estimate of the real opportunity cost of capital for low risk projects. If undertaking the project crowds out other investment projects, this may be taken to be the minimum required rate of return. An alternative approach is to use a lower discount rate (5%) to represent the underlying rate of social time preference, but to combine it with a minimum required benefit/cost ratio, say, 3:1 in order for the project to proceed. Within a given capital budget, this latter approach is relatively more favourable to long-lived assets such as transport projects which yield benefits far into the future. See Section 4.9.

4.4.6 Care should be taken to ensure that project specific parameters such as the start year and investment period are considered for each project individually, so that the discounted costs and benefits can reflect differences in timing between projects. For the parameters that are common to all projects, consistency here should enable as realistic a comparison as possible between alternative uses of the available budget.

4.4.7 For many infrastructure projects, the useful life of the asset created will exceed 30 years. In these cases, it is acceptable to include in the benefits for the final year of the operating period a *residual value.* This serves to capture any remaining net benefit, that is any excess of the remaining user benefits over infrastructure maintenance and operating costs, up to the end of the technical life of the asset. Bear in mind, however, that in the CBA calculations, net benefits beyond the 30 year operating period will be heavily discounted (for example, for a base year of 2000, the discount factor on benefits in year 2035 will be 0.181 at 5%, or 0.019 at 12%) and that similar projects should be treated similarly. The assumptions made in calculating residual values should be stated as footnotes to the CBA results.

4.4.8 In general, demand forecasts should be undertaken for a minimum of two years – the opening year (defined as the first full year of operation) and the design year which should be chosen taking account of available macro-economic forecasts and other data (typically around the 10^{th} year of operation). The opening year is required in order to check that the project is worth undertaking now. The design year is required to check that the design is appropriate for the forecast volume of traffic. Both are required in order to establish the benefit and cost streams over the appraisal period (see paragraph 4.8.4 below).

4.5 Investment costs

4.5.1 This is the first impact within the CBA. Drawing on the definitions adopted within the EUNET project (Nellthorp, Mackie and Bristow, 1998; PLANCO, 1997) investment costs for infrastructure should include the following components:

- planning costs - including the design costs, planning authority resources and other costs incurred after the decision to go ahead;

- land and property costs - including the cost of acquiring land needed for the scheme (and any associated properties), compensation payments necessary under national laws and the related transactions and legal costs; and

- construction costs - including materials, labour, energy, preparation, professional fees, contingencies and periodic maintenance.

4.5.2 In some cases, where an integrated project is undertaken to provide new infrastructure and rolling stock, it is appropriate to include the rolling stock within the capital costs, with an appropriate life. In such cases, in order to avoid double counting, no depreciation or interest element should be included in the vehicle operating costs in respect of this rolling stock. In the more general case where new infrastructure changes are not part of the investment package, we recommend that changes in vehicle requirements to carry the traffic should be included in Vehicle operating costs, in the form of a depreciation charge relating partly to time and partly to distance (see para 4.6.4 below).

4.5.3 Investment cost will be measured in the agreed currency of the appraisal per year for each project. Where possible, an investment profile should be given indicating a definite start year and detailing how the flow of investment will vary in each year of the investment period. Where such detailed information is not available, the preferred alternative is for analyst to allocate the total investment cost between years in a way that is consistent with other comparable projects.

4.5.4 Other key recommendations relating to investment costs are that:

- environmental impact mitigation measures should be included in the project design and costed accordingly as part of the investment costs; and

- in the interests of consistency between appraisals, localised shadow pricing of labour will not be allowed. Potential impacts on employment in areas with high levels of unemployment or underemployment should be reported within Wider Economic Impacts (Section 3.5).

4.5.5 Note that any disruption to existing users during the investment period should be estimated using the same values of time as are used for travel time savings arising from the scheme, and should be included in the User Benefits component of the CBA results, *not* Investment Costs. Note also that periodic maintenance is included under Infrastructure Operating and Maintenance Costs, which are discussed in the following section.

4.5.6 In the disaggregated CBA (example Table V.4) investment costs should be allocated between groups (operators and government) according to the expected shares in which the costs will be met.

4.6 Operator cost and revenue impacts

4.6.1 These include the following recurrent (annual) costs and revenues:

- changes in infrastructure operating and maintenance costs;
- changes in the vehicle operating costs of public transport systems;
- changes in the revenues received by operators of transport infrastructure and services.

Infrastructure operating and maintenance costs

4.6.2 Infrastructure operating and maintenance costs are defined as consisting of:

- the costs of infrastructure operation (for example, signalling/traffic control);
- the costs of maintenance (for example, cleaning, minor repairs, winter servicing); and
- the costs of renewal (for example, road resurfacing).

4.6.3 Maintenance costs and renewal costs may be linked to investment costs. Appropriate measures differ between modes as shown in Table 4.4.

Table 4.4: Measures of System Operating and Maintenance Cost

Mode	Cost Items and Measures (all per annum)

Road	Maintenance (euro per km of road) Winter Servicing (euro per km of road) Renewal (euro per million freight vehicle km)
Rail	Operation and Maintenance (euro per km of railway)
Inland Waterways	Maintenance (euro per km) Operation of Locks (euro per lock)
Ports	Maintenance per euro invested
Aviation	Operation and Maintenance per euro invested

Source: PLANCO, 1997

VOCs of public transport systems

4.6.4 Vehicle operating costs (VOCs) for public transport systems will include the following items, comprising both *standing (or time-dependent) costs*, which do not vary with distance travelled, and *distance-dependent costs* (PLANCO 1997; PLANCO 1998):

Standing cost components:

- Depreciation (time-dependent share)
- Repair and Maintenance Costs

Distance-dependent components:

- Overheads
- Administration
- Operating cost components:
- Personnel Costs (that is, costs associated with bus and coach drivers, and the crew of trains, ferries and passenger aircraft)
- Depreciation (distance-related share)
- Fuel and lubricants

4.6.5 Note that Personnel Costs include drivers' wages. Care is therefore needed to avoid double-counting of this component with the Time values, both in modelling and in appraisal.

Total operator costs

4.6.6 Calculation of the change in costs faced by operators should be made by comparing the do-something and do-minimum scenarios using the measures given above, with costs adjusted to a year 2000 price basis as necessary. Elements of operators' costs which are based on network length or vehicle-km will need to calculated for links within the study area where such costs change significantly as a results of the project - a spreadsheet may be helpful for this calculation too.

Operator revenues

4.6.7 Changes in the revenues received by operators of transport infrastructure and services will be estimated by applying the appropriate user charges (or average user charges if detailed data in unavailable) to the model output data on numbers of trips. The impact of a particular transport infrastructure project will be taken as:

revenue in the do-something scenario **minus** revenue in the do-minimum scenario.

Net impact on operators

4.6.8 The net impact on operators in a particular year will be given by the change in revenue less the change in costs.

4.7 User benefit estimation

4.7.1 A core element of the cost-benefit analysis is the estimation of user benefits. For many projects the benefits to travellers in terms of time and money savings will be central to the economic case for the project.

4.7.2 Three fundamental concepts underlying the definition of user benefit in transport CBA are *generalised cost, willingness to pay,* and *consumer surplus:*

- Generalised cost is an amount of money representing the overall disutility (or inconvenience) of travelling between a particular origin and destination by a particular mode. In principle this incorporates all aspects of disutility including the time given up, money expenditure and other aspects of inconvenience/discomfort. In practice the last of these is usually disregarded.

- Willingness-to-pay is the maximum amount of money that a consumer would be willing to pay to make a particular trip. This can be best interpreted as a maximum generalised cost that they are willing to pay in order to get from their origin to their destination.

- Consumer surplus brings these together, since it is defined as the excess of consumers willingness-to-pay over the actual generalised cost of travel.

4.7.3 The basic measure of user benefit is the change in consumer surplus resulting from a change in the network. This requires us to

- Estimate the volume of travel by mode and trip category for each origin/destination pair. If the volume of travel is expected to respond to the change in network quality, both the volume "with" the change in place and the volume "without" the change need to be modelled or estimated for the base year and forecast for future years.

- Estimate the change in generalised costs of travel by mode and try categories for each origin/destination pair.

- Combine together the trip volume and cost change information so as to calculate the aggregate user benefits summing over all origins and destination. The detail of the required procedure is discussed in Annex II.

Calculation of safety benefits

4.7.4 By convention, safety is treated differently from the other components of user benefit. Rather than being included as a component of generalised cost per trip, accidents and casualties are treated as external costs arising from the transport system, which can be evaluated by applying unit values per accident and per casualty to forecast data on accident and casualty numbers by mode.

Values for vehicle operating costs (VOCs)

4.7.5 This component of user benefits relates to car VOCs and own-account freight VOCs only, since all other VOCs are met by transport operators, not by users (see Section 4.6 above for calculation of operator costs). In appraising transport infrastructure projects, the World Bank's HDM model should be used to estimate vehicle operating costs for these particular modes of transport at the link or origin-destination level. This data should be entered into the calculation of generalised cost in the do-minimum and the do-something scenario, in order to calculate the corresponding user benefit.

4.8 Summary measures of social value

4.8.1 The social value of a particular project in terms of transport efficiency and safety, can be summarised using one or more of the following measures:

- the Net Present Value (NPV);
- the Benefit/Cost Ratio (BCR);
- the Internal Rate of Return (IRR).

4.8.2 Each of these summary measures compares the benefits of the project with the costs, although there are differences in definition which give each measure a different appeal. Their features are summarised in Box 4.8.

4.8.3 To calculate most of the summary measures various manipulations of the user benefit and cost data are needed, namely: interpolation, discounting and aggregation. Guidance on these steps is given below the Box.

Box 4.8: Summary measures of social value

Net Present Value (NPV) is the discounted sum of all future benefits less the discounted sum of all future costs over the appraisal period as a whole. In a world with no constraint on investment funds, there would be a strong case for taking forward all projects with a positive NPV.

In order to calculate the NPV correctly, realistic estimates are required of the streams of benefits and costs over the appraisal period (typically around 30 years). The key to determining both these streams is knowledge of the times at which the various elements would come into play. Investment costs will typically be incurred prior to the date of opening, whilst operating costs (for example, highway maintenance) and user benefits would arise after the year of opening. User benefits and operating costs/revenues can be estimated from model runs for two or more years, and the stream of benefits derived by interpolation and extrapolation (see below) between the benefits for the modelled years.

Benefit/Cost Ratio (BCR) is given by the ratio of the discounted sum of all future costs and benefits except investment costs to the discounted sum of investment costs. The BCR is therefore a value for money measure, which indicates how much net benefit would be obtained in return for each unit of investment cost. This is clearly relevant in the real-world situation of limited investment funds. The same points about deriving streams of benefits and costs apply the to the BCR as apply to the NPV.

Formulae for the NPV and BCR will be found in CBA textbooks, a good example of which is Pearce and Nash (1981).

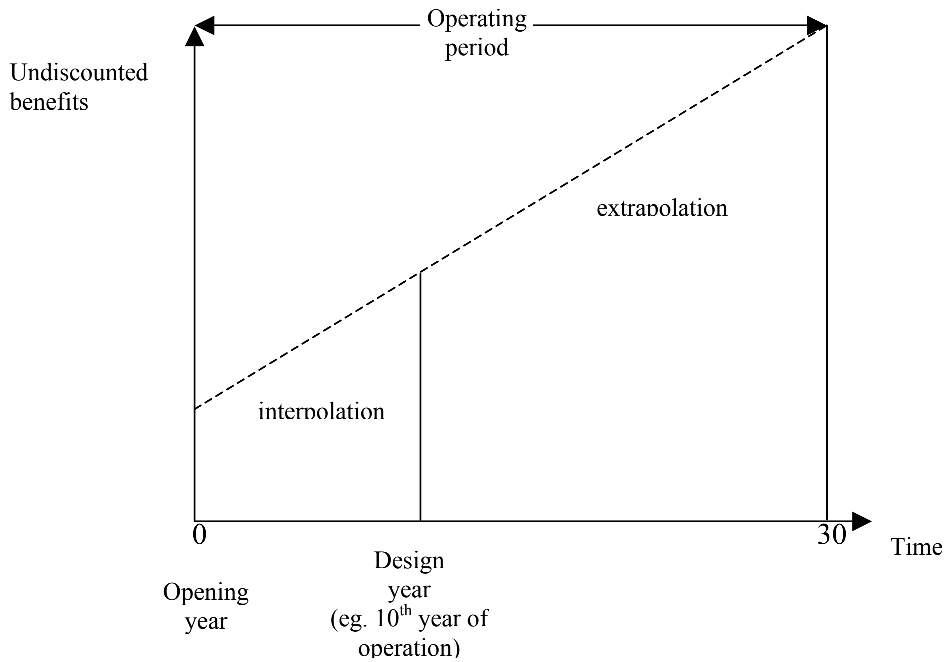
Internal Rate of Return (IRR). Whereas the previous two measures require a test discount rate to be specified, the IRR reports the average rate of return on investment costs over the appraisal period. This can be compared with the test discount rate to see whether the project yields a higher or lower return than is required to break even in social terms. Calculation of the IRR and issues surrounding it are discussed in Pearce and Nash, Chapter 4 and in the other cost-benefit texts listed.

Interpolation and extrapolation

4.8.4 Given user benefit and operator cost/revenue estimates for two (or more) forecast years at constant base year prices, streams of benefits and costs should be generated by a process of interpolation and extrapolation. The minimum requirement is that the model should be run for the project-opening year and for the design year. The default assumption is that interpolation and extrapolation should be linear, that is, along a straight line. A linear path is reasonable if, for example, traffic is expected to grow at a constant rate over time. However, in some cases linear growth of the benefits stream over time may not be a valid assumption, for example, if capacity constraints on the network mean that demand in the later years simply could not be met. The realism of benefit growth assumptions should be checked before completing this stage.

4.8.5 The output from interpolation and extrapolation is a set of undiscounted cost and benefit streams at base year prices. See Figure 4.2.

Figure 4.2: Interpolation and Extrapolation of Benefits – an example



Discounting

4.8.6 In order to obtain discounted streams of benefits and costs (needed for the NPV and BCR), every item in the undiscounted streams of benefits and costs should be subject to the following formula:

$$NPV = \sum_{t=0}^{t=n} \frac{B_t - K_t}{(1+r)^t}$$

Where project life runs from 0 to n

B_t is the undiscounted benefit in time period t

K_t is the undiscounted cost in time period t

r is the social discount rate.

Discussion of the calculation of benefit and cost is contained in Annex III

4.8.7 Social discount rates of 5% and 12% should be used to calculate the NPVs.

Aggregation

4.8.8 Finally, to calculate Present Values of Costs and Present Values of Benefits, the discounted benefit streams should simply be summed across all years of the appraisal period.

4.9 Capital budgeting issues

4.9.1 The discussion so far has taken place in terms of a simple choice between accepting a project or rejecting it. But in practice, life is rarely that simple, and there are three more complicated cases which need to be considered.

4.9.2 In practice, all transport infrastructure projects involve choices between mutually exclusive alternatives – choices of horizontal and vertical alignment, design standards for junctions, capacity, signalling and control systems and so on. In practice the number of potential combinations is very large and not all of these can be assessed using a full cost-benefit approach. But we do recommend that

- economic analysis, simplified if necessary, is introduced at an early stage in the planning and design process as a tool of value engineering.
- the final appraisal should include the assessment of a suitable range of project options. In particular it is not acceptable to consider only a do-nothing option and an engineering ideal with no intermediate options. Lower cost, or staged, options must be properly considered.
- where a range of mutually exclusive alternatives is appraised, the prime indicator of social benefit is the Net Present Value of each alternative. In a world where the discount rate correctly represents the social opportunity cost of capital, the project option with the highest NPV will rank highest in terms of the CBA.

4.9.3 However, an extremely common situation is one where there is capital rationing. That is, not all projects which secure a positive NPV at a discount rate of 12 per cent can be accommodated within the capital programme of the implementing agency. This will almost certainly be true if a lower discount rate of 5 per cent, reflecting social time preference is used. In such situations of capital rationing, projects are required not only to pass the discount rate test, but also to show a benefit: cost ratio which is greater than the marginal benefits:/cost ratio in the capital programme as a whole. An example is shown in Fig 4.3.

Figure 4.3.

BCR (PVB/PVK)

Accept

3

Acceptable but unfunded

1

Reject

In this case, the capital scarcity condition is such that only projects which yield a benefit/cost ratio (PVB/PVK) of at least 3:1 can be accepted into the programme. There will be a category of projects which are acceptable but unfunded unless capital availability improves. The minimum required benefits cost ratio should be determined across sectors in the light of macroeconomic conditions.

4.9.3 Where conditions of capital rationing apply in the context of mutually exclusive projects, it is necessary to consider and report the incremental benefit/cost ratios of each branch of capital. An example is given in Box 4.9.

BOX 4.9: INCREMENTAL ANALYSIS

EXAMPLE 1

Relative to the do minimum base case, two options exist – low cost option A and high cost option B.

	PVK	PVB	NPV	BCR
Option A	60	180	120	3
Option B	100	240	140	2.4
Option (B-A)	40	60	20	1.5

Suppose the marginal benefit/cost ratio required is 2, then in this case option A is chosen; the incremental BCR of upgrading from A to B is not sufficiently high to justify using 40 units of capital in this way

EXAMPLE 2

	PVK	PVB	NPV	BCR
Option A	100	250	150	2.50
Option B	120	280	160	2.33
Option C	150	360	210	2.4
Option D	200	430	250	2.15
Option (B-A)	20	30	10	1.5
Option (C-B)	30	80	50	2.66
Option (C-A)	50	110	60	2.2
Option (D-C)	50	70	20	1.4

In this case, there are four mutually exclusive options. Assume again that the minimum acceptable BCR is 2. First, lay out the options in ascending order of capital cost. All four options have a BCR greater than 2, so we need to consider the incremental yield. Option A is the lowest cost option and relative to the base has a BCR of 2.5, so is acceptable. The incremental return on B over A is 1.5 – not acceptable. Comparing C with A, the incremental cost of 50 yields an incremental benefit of 110, so the incremental BCR of 2.2 is acceptable. However, option D is not acceptable. So option C is chosen.

Conclusion - where there are multiple options and capital rationing, choose the largest project option for which:

(a) BCR is greater than the minimum required AND
(b) incremental BCR relative to next best option is greater than the minimum required.

4.9.4 In order to make this analysis practical, there will need to be discussion of the appropriate definition of the constrained resource. Is it all capital? Is it the capital contributed by the country? Is it the present value of the capital plus future maintenance costs? Is it the net impact on the country public budget? The BCR needs to be defined securely and consistently.

4.9.5 The third dimension is that of project timing. It needs to be demonstrated not only that a project is acceptable, but also that it should be implemented at the planned time rather than being deferred to a future date. A suitable diagnostic test for this is the first year rate of return test. If the ratio of the present value of benefits in the first full operating year to the present value of capital costs is less than the discount rate, then deferment is indicated, and the NPV of undertaking the project at different starting dates should be addressed.

4.10 Presentation of the results

4.10.1 In presenting the results of the cost-benefit analysis, the key information to report will be:

- initial assumptions and scenario definitions;
- CBA parameters (including Start Year, Opening Year);
- Summary Measures of social value;
- disaggregated CBA results, highlighting the following distributional issues within the overall costs and benefits:
    - shares of international traffic versus domestic traffic in user benefits;
    - users benefits versus net impact on operators;
    - shares of user benefits by mode;
    - composition of user benefit by item of benefit (Time, VOCs, etc);
    - shares of time savings made up by personal travel in working time, personal travel in non-working time and freight movement;
    - shares of operator costs and revenue by mode;
    - investment costs by group (that is, private operators, national government, financial institutions).

This disaggregated information could be presented in a range of different formats, some of which would be more suitable for particular uses of the appraisal outputs. However, one solution is an overall summary on a single sheet.

4.10.2 A set of example reporting tables is given in Annex V, to assist in the process of developing reporting formats for transport infrastructure projects.

4.10.3 Finally, note that certain information will need to be made available to financial institutions. This will include the undiscounted cost and benefit streams, as well as the output information listed above.

5 UNCERTAINTY

5.1 Introducing uncertainty into project appraisal

5.1.1 The social, economic and financial impacts of major transport schemes are frequently subject to substantial uncertainty. The benefits often depend upon the interaction of social and economic factors whose growth paths are difficult to forecast over a long time period. Further, there are usually some uncertainties surrounding construction costs, and although these uncertainties may not be so great as the benefit-side uncertainties, because they occur early in the evaluation period, discounting does not diminish their size.

5.2 Scenario analysis for transport infrastructure projects

5.2.1 A common approach to the problem of uncertainty is to create a range of scenarios and to test the robustness of the project to those scenarios.

5.2.2 Scenarios may consist of:

- future economic and traffic growth rates
- trends in fuel prices
- the speed of development of the rest of the transport network
- the speed of integration with the EU and/or the world economy.

5.2.3 These scenarios need to be developed in discussions with Ministries of Finance and Planning, and IFIs, and should be consistently applied across projects and sectors. An example is shown in Table 5.1 of the scenarios agreed for the TINA network and reported in NEA et al, 1999.

5.2.4 The aim of this set of scenario tests is to demonstrate that the performance of the project in terms of of social value (Box 4.8) is robust to alternative future scenarios. Testing should be carried out according to the following steps, repeated once for each scenario:

- use the data in the scenario specification to revise the demand forecasts for the project in the do-minimum and do-something scenarios;
- re-run the cost-benefit analysis within the spreadsheet (or alternative computational tool);
- report the NPV, BCR and IRR results (example output Table V.3).

5.2.5 Clearly, repeating the cost-benefit analysis for each scenario uses up a great deal of appraisal resources. Therefore it is strongly recommended to agree with the relevant IFIs and the implementing agency which scenarios will be tested BEFORE embarking on the CBA process.

5.3 Other sensitivity tests

5.3.1 In addition to the scenario tests above, it would also be appropriate to report on the level of uncertainty associated with investment costs and the values of time and safety, and the implications for project NPV, BCR and IRR. Depending on the level of uncertainty, +/- 10% or +/-50% tests on these values should be conducted; both separately and in combination with the traffic scenarios above Again, given the large number of possible combinations, it is best to agree on the sensitivity tests to be carried out BEFORE embarking on the CBA.

5.3.2 Cost-benefit analysts, and users of CBA should be aware of a wide range of sources of error in appraisal (see Annex VII for a discussion of UK appraisal practice which, however, is of general relevance). The appraisal should guard against over-optimism, and the sensitivity of the appraisal to key assumptions and parameters should be tested and reported.

Table 5.1: Future Scenarios for the TINA Network (Source: NEA/INRETS/IWW, 1999)

Scenario Name	Economic Growth	Infrastructure Development	Integration into the European Union
Scenario A	Low	Existing infrastructure	Low integration
Scenario B	Moderate	Existing infrastructure	Low integration
Scenario B1	Moderate	Existing infrastructure	Low integration
Scenario C	Moderate	Partly completed network	Moderate integration
Scenario D	Moderate	Completed TINA network to Western standards	High integration
Scenario D1	Moderate	Completed TINA network to Western standards	High integration
Scenario E	High	Completed TINA network to Western standards	High integration

<u>GDP Growth Scenarios 1996-2015</u>

Low	1.3% p.a. to 5.6% p.a.
Moderate	2.1% p.a. to 6.5% p.a.
High	3.6% p.a. to 7.3% p.a.

<u>Transport Network Definitions</u>

Existing infrastructure	1995 base network - unchanged to 2015
Partly completed network	investment takes places at a rate of 1.5% of GDP p.a.
Completed TINA network to Western standards	18500km of roads; 20700km of railways; 4000km of inland waterways; 40 airports; 15 seaports; 52 river ports; 84 terminals

<u>Timings for Integration into EU</u>

Low integration	Czech Republic and Poland in 2010; Hungary and Slovenia in 2012; others after 2015
Moderate integration	Czech Republic, Hungary, Poland and Slovenia in 2005; Estonia in 2010; others after 2015
High integration	as for Moderate Integration

6 CONCLUSION AND DISCUSSION

6.1 The purpose of this paper is to provide appraisal guidance for transport infrastructure project proposals. We recommend the use of a Framework approach containing at its core a Cost-Benefit Analysis of those elements that can justifiably be valued in monetary terms. In addition to this, there should be reporting of environmental and broader policy impacts that are brought together with the Cost-Benefit Analysis in a coherent way to produce an overall assessment.

6.2 The initial stages of the process include the definition and initial screening of candidate projects. For those projects, which are then carried forward to the formal appraisal, it is necessary to assess the effect (or impact) on a key group of indicators. These include (but are not restricted to) transport user benefits, transport system efficiency, safety, environmental impacts, wider economic inputs, other policy impacts and financial implications.

6.3 Comparing the state of these indicators in the do-minimum scenario with their state in the do-something scenario assesses the effect of the project. In order to form this comparison it will be necessary to collect data and other relevant information relating to the indicators. The Cost-Benefit Analysis, which forms the core of the assessment, is then calculated using both the computed costs and computed benefits.

6.4 It is our recommendation that spreadsheet software (Microsoft Excel or similar) should be used in carrying out the necessary calculations, for the study area as a whole and for all the modes, trip purposes, benefit items and international/domestic traffic within it. Transport administrations or their consultants may even wish to write routines in a programming language such as Visual Basic or C to ease the process of carrying out repeated steps for many projects. Storing data in a relatively disaggregate form within a spreadsheet or similar would assist the process of sensitivity testing (on particular parameters or values), ease the updating of information and allow decision-makers to form comparisons more readily.

6.5 The analysis in Sections 3-5 has been set out in the context of the appraisal of a single project. However, the real world is more complex; typically the decision-makers need to assure themselves that the chosen project is the *best* of the available alternatives, and that the project is sufficiently high in the merit or ranking order to warrant funding. The analysis must therefore be capable of allowing for the existence of many project alternatives and should facilitate prioritisation and ranking, although it will not *determine* ranking: the task of weighing up the economic, environmental and policy impacts rests with the decision-makers themselves.

6.6 It is not possible to undertake a completely exhaustive appraisal of all the project alternatives. For an infrastructure project, there are a large number of combinations of routeing, alignment, layout and capacity. Normally, many of these choices will be made by reference to design standards and engineering judgement, using appropriate reference manuals. However, especially where strategic routeing options exist, the full appraisal of a few alternatives should be undertaken so as to demonstrate that the preferred option is superior not just to the do-minimum but to the available alternatives. This should help to minimise the risk of over- or under design. For large projects where many technical choices exist, such as bridges and tunnels, many alternatives may need to be evaluated.

6.7 In theory, a full comparison between the project alternatives will be needed on each of the criteria listed in the appraisal framework. In practice, however, it is likely that for several of the impacts, the performance of the project options will be similar or identical so that in comparing alternatives, it should be possible to focus down on the respects in which the project alternatives differ. These are likely to be the cost-benefit analysis plus any location-specific effects of particular alternatives such as loss of heritage or natural assets, or specific opportunities created.

6.8 In terms of the cost-benefit analysis, the most useful approach is some form of *incremental analysis*. The decision taker should consider whether the net differences in user benefit, revenue and operating costs justify the additional capital outlay for each project alternative, the analysis should list the alternatives in ascending order of capital cost and show the incremental Net Present Value for each increment of capital outlay.

6.9 A common situation is that in which not all projects that pass the test of acceptability discussed above can actually be funded. Some form of capital rationing or budget constraint exists at sector or national level. In this situation, prioritisation becomes important; it is necessary to use the constrained resource, typically public sector finance, as efficiently as possible. This may affect both project appraisal and project financing

6.10 In terms of project appraisal, in conditions of capital rationing, it is recommended that some form of explicit prioritisation or ranking exercise is undertaken between the projects being considered, whether at national or international level. The key indicator for this will be the benefit-cost ratio of projects (see Box 4.9) because this is the indicator of benefit per unit of capital cost, obtained from each project.

6.11 Note however that a single indicator such as the benefit-cost ratio will not take account of differences between projects in the environmental or other policy dimensions, and is an incomplete measure. The environmental assessment should be conducted in a way which is consistent with the principles and advice regarding Strategic Environmental Assessment. Wider economic and social impacts such as effects on economic activity, employment and social cohesion are relevant to the appraisal but require careful treatment (see Annex IV).

6.12 Finally, to reach s decision requires the decision-maker to balance or trade-off the performance of the project in terms of the Cost-Benefit, environmental and wider policy dimensions. This is the art of decision-maker judgement which socio-economic analysis is intended to inform and support. It is this mixture of good quality socio-economic analysis aiding good judgement in decision-making which is necessary to obtain best social value from limited investment resources.

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ANNEX I – LIST OF ACRONYMS

BCR	**Benefit/Cost Ratio.** A summary measure of the project's performance in the cost-benefit analysis. See Section 4.8.
CBA	**Cost-benefit analysis.** An established framework for the economic appraisal of transport and other projects. For an overview of CBA in the transport sector, see the Chapter 'Cost-Benefit Analysis' in Button and Hensher (2001).
CEC	**Commission of the European Communities.** Former name of the European Commission.
CIS	**Commonwealth of Independent States.** Grouping of 12 former republics of the USSR: Azerbaijan Republic, Republic of Armenia, Republic of Belarus, Georgia, Republic of Kazakhstan, Kyrgyz Republic, Republic of Moldova, Russian Federation, Republic of Tajikistan, Turkmenistan, Republic of Uzbekistan and Ukraine.
EBRD	**European Bank for Reconstruction and Development.**
EC	**European Commission.**
EIA	**Environmental Impact Assessment.** See SEA.
EIB	**European Investment Bank.**
EU	**European Union.**
HDM	**Highway Development and Management System.** Software system (HDM-4 is current version) to assist road network managers in maintaining and developing the network.
IFIs	**International financial institutions.** Includes, amongst others, The World Bank, European Investment Bank and European Bank for Reconstruction and Development.
IRR	**Internal Rate of Return.** A summary measure of the project's performance in the cost-benefit analysis. See Section 4.8.
ISPA	**Instrument for Structural Policies for Pre-Accession.** Community aid for the environment and transport in the candidate countries of Central and Eastern Europe. (see http://europa.eu.int/comm/regional_policy/funds/ispa/ispa_en.htm).

NPV	**Net present value.** A summary measure of the project's performance in the cost-benefit analysis. See Section 4.8.
PVB	**Present value of benefits.** Sum of the discounted benefits of the project.
PVK	**Present value of capital cost.** Sum of the discounted capital costs of the project.
SACTRA	**Standing Advisory Committee on Trunk Road Assessment.** UK committee appointed by the Transport Minister to investigate key issues in transport appraisal. Notably, SACTRA considered the relationship between 'Transport and the Economy' (SACTRA, 1999) and the issue of to what extent 'Roads Generate Traffic' in the UK (SACTRA, 1994).
SEA	**Strategic Environmental Assessment.** An analysis of the environmental effects of projects. (see http://europa.eu.int/comm/environment/eia/sea-support.htm).
TINA	**Transport Infrastructure Needs Assessment.** Process for defining a pan-European transport network in Central and Eastern European countries, funded by the EU PHARE programme. Final report produced October 1999 (TINA Secretariat, 1999).
UK	**United Kingdom.**
UNECE	**United Nations Economic Commission for Europe.**
VOCs	**Vehicle operating costs.** Including fuel and other costs of transport vehicle operations. Note that in Strategic Environmental Assessment, 'VOCs' may sometimes be used to mean 'Volatile Organic Compounds'. To avoid confusion, it is worthwhile stating which meaning is intended.

ANNEX II -DATA NEEDS

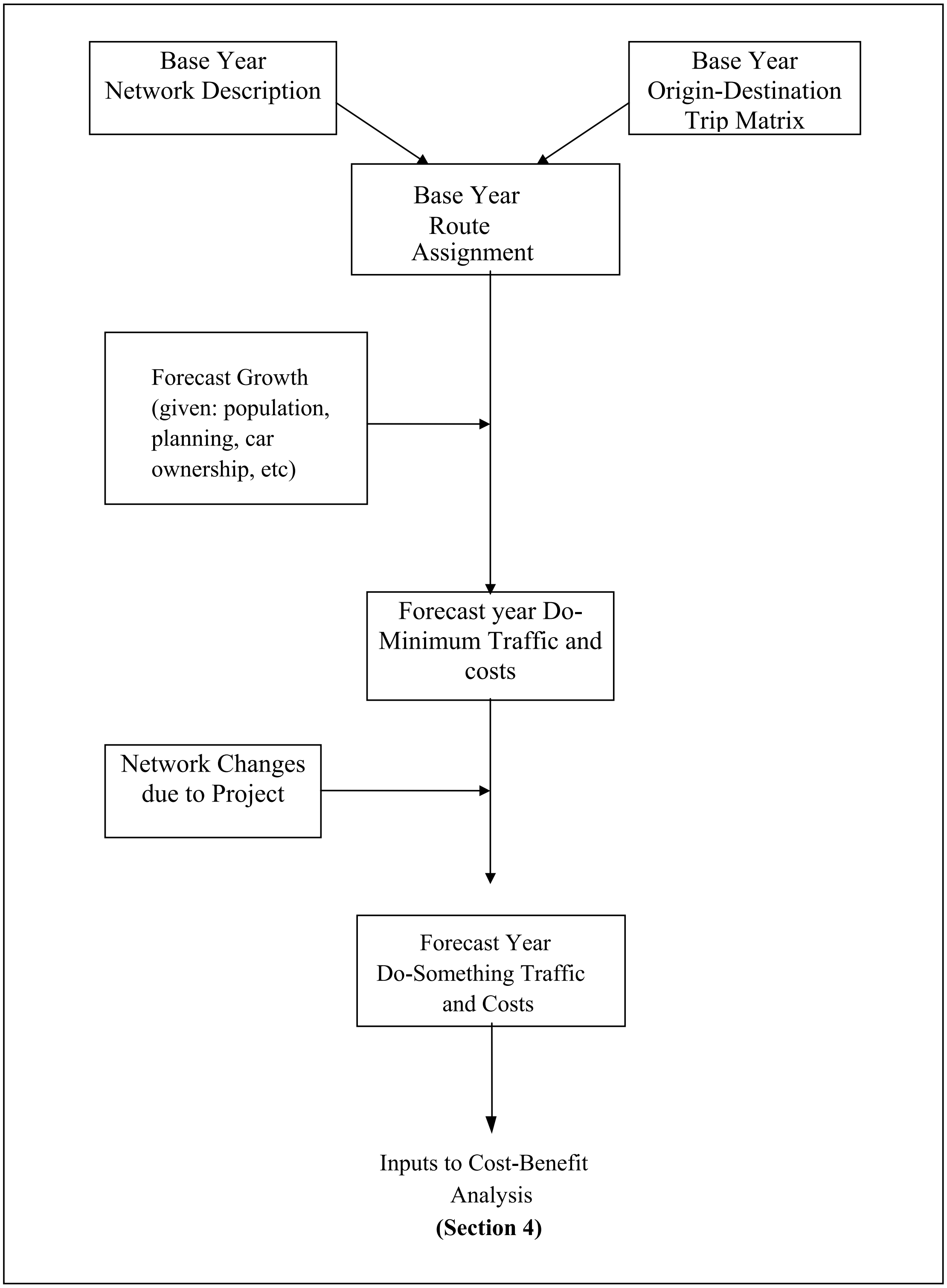
I.1 The Cost-Benefit Analysis is logically the last of a series of steps in the traffic and economic assessment. The quality of the Cost-Benefit Analysis is largely dependent on the quality of the input data and traffic model output that feed it.

I.2 A large number of books and manuals have been written about traffic modelling and forecasting (see for example DOT (1991) for the UK official advice and practice). A simple sketch of the process is shown in Figure I.1, from which it can be seen that key requirements are:

- a network description (Multi-Modal if necessary) describing the network in terms of distances, quality, capacity and speed/flow relationships;
- a base year origin-destination trip matrix output from a trip distribution model
- a base year traffic assigned to the network (Multi-Modal if necessary) and validated against observed flows
- forecasts of growth or change due to the external factors which influence travel demand - population, income, car ownership, regional planning data, fuel prices etc.
- applying the external growth forecasts to the trip matrix so as to generate forecast year do-minimum traffic and costs. Where congestion is relevant, capacity restraint must be used to ensure traffic and cost forecasts are realistic
- incorporating the network changes due to the project, and forecasting do-something traffic and cost levels. Depending on the situation it may be appropriate to allow for trip redistribution, mode split and release of suppressed traffic as well as traffic reassignment. Again, the realism of the forecast traffic flows and costs in relation to network capacity must be verified.

I.3 The Cost-Benefit Analysis takes as its starting point the do-minimum and do-something forecasts of traffic and costs and proceeds from these.

Figure II.1: Key Stages in Forecasting Transport Flows and Costs



ANNEX III - CALCULATION OF USER BENEFITS

III.1 The following paragraphs seek to outline how the user benefits can be calculated from basic transport data and to draw attention to some of the key practical issues which will arise when attempting to estimate the user benefits of transport infrastructure projects.

Definition of user benefit

III.2 Three fundamental concepts underlying the definition of user benefit in transport CBA are *generalised cost*, *willingness-to-pay* and *consumer surplus.* Defining these first:

- generalised cost is an amount of money representing the overall disutility (or inconvenience) of travelling between a particular origin (i) and destination (j) by a particular mode (m). In principle this incorporates all aspects of disutility, including the time given up, money expenditure and other aspects of inconvenience/discomfort, but in practice the last of these is usually disregarded.

- willingness-to-pay is the maximum amount of money that a consumer would be willing to pay to make a particular trip (this can best be interpreted as a maximum generalised cost that they are prepared to accept in order to get from i to j);

- consumer surplus brings these together, since it is defined as the excess of consumers' willingness-to-pay over the prevailing generalised cost of i-j travel. Total consumer surplus (CS^0) for a particular i and j in the do-minimum scenario is shown diagrammatically in Figure III.1.

III.3 For the market for travel between i and j (assuming for simplicity that only one mode exists):

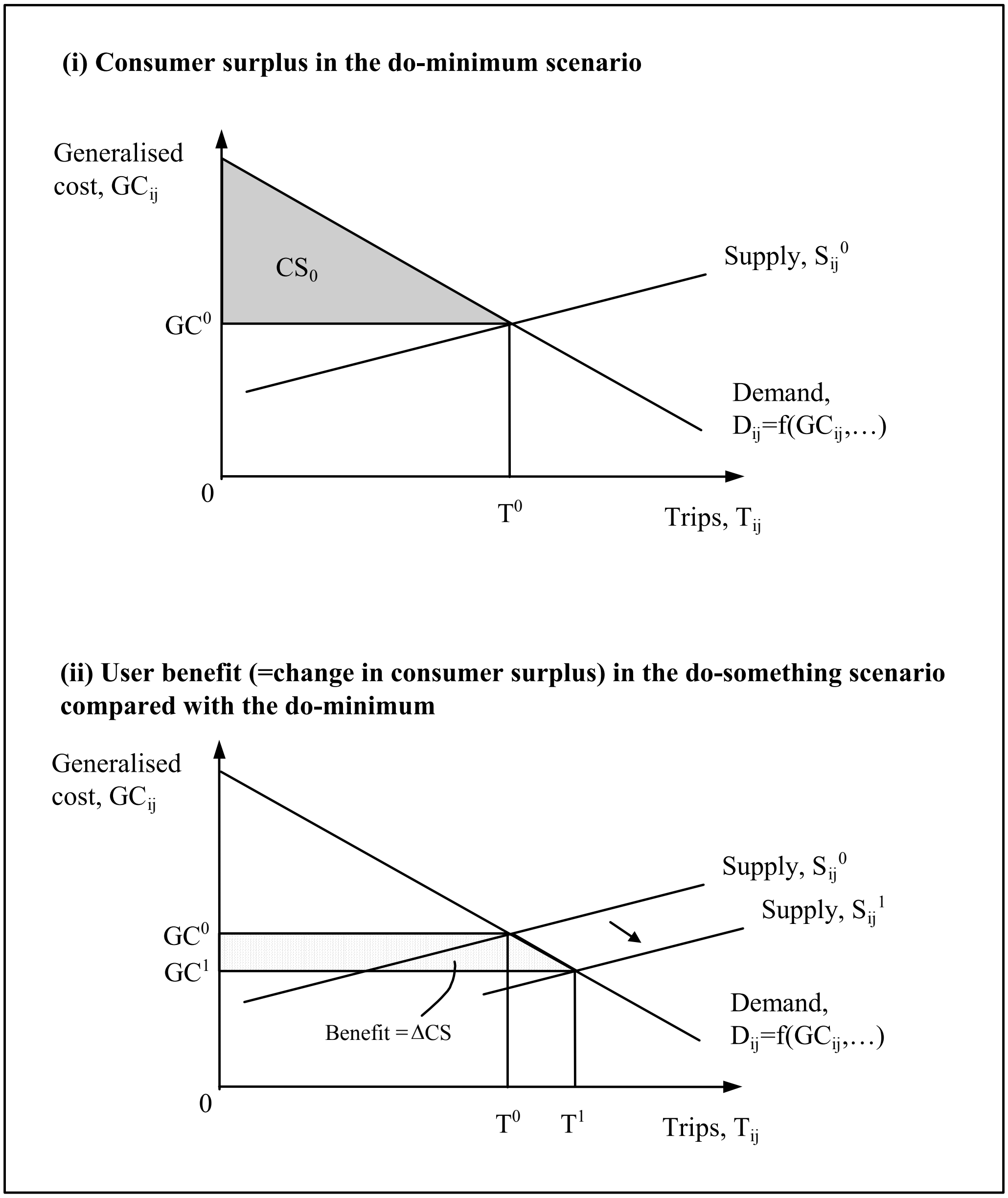
$$\text{User Benefit}_{ij} = \text{Consumer surplus}_{ij}^{1} - \text{Consumer surplus}_{ij}^{0}$$

where 1 indicates the do-something scenario and 0 indicates the do-minimum.

III.4 In Figure III.1(i), consumers' willingness-to-pay is represented by a downward-sloping demand curve, and transport supply conditions are represented by an upward-sloping supply curve. The intersection of demand and supply determines equilibrium generalised cost. Consumer surplus is represented by the area beneath the demand curve and above the equilibrium generalised cost, area CS^0.

III.5 In Figure III.1(ii), it is assumed that there is an improvement in supply conditions, due for example to an improvement in the road or rail infrastructure. The reduction in equilibrium generalised cost that results from this improvement leads to an increase in consumer surplus, which gives the user benefit equal to the area ΔCS.

Figure III.1: Consumer surplus and user benefit



Calculating user benefits in practice

III.6 Although the demand curve is shown as a straight line in Figure III.1, that is a simplification of reality, since the shape of the demand curve is not usually known. In fact all that is usually known are GC and T in the do-minimum, plus a forecast of GC and T in the do-something.

III.7 It is conventional in transport appraisal to deal with this by making the assumption that the demand curve between (GC^0,T^0) and (GC^1,T^1) is linear, and therefore that the user benefit can be approximated by the following function, known as the *rule of a half:*

$$\Delta CS = \int_{GC_1}^{GC_0} D(GC)\, dGC \approx \text{Rule of a Half (RoH)} = \frac{1}{2}\left(GC_0 - GC_1\right)\left(T_0 + T_1\right)$$

III.8 It follows from the above that when the effect of a transport infrastructure project can be captured in the form of a reduction in generalised costs between particular origins and destinations, the rule of a half is a useful approximation to true user benefits. In fact, it is recommended that the rule of a half be used to calculate user benefits in most cases.

III.9 There are, however, certain special circumstances where the rule of a half is not applicable. These are:

- introduction of completely new modes in the do-something scenario - for example, high speed rail, urban light rapid transit, or even a new conventional railway where none exists in the do-minimum;

- large changes in the generalised cost of modes. The bigger the proportionate reduction in generalised cost brought about by a transport infrastructure project, the less reliable the rule-of-a-half approximation becomes. The recommendation here is that, as a rule of thumb, if the project results in a >25% reduction in average generalised cost from origin to destination for trips using the improved infrastructure, this should be reported alongside the CBA results in the output tables;

- any changes in the quality of modes (for example, introduction of more comfortable or more reliable trains) unless these have been converted into generalised cost terms and treated as a downward shift of the supply curve .

III.10 If these circumstances should arise within the investment programme, specialist advice should be sought. Some guidance is given in MVA/OFTPA/ITS (1994, Appendix D) but further technical assistance may be needed given the complexity of the problem.

III.11 Extending the user benefit measure from one origin-destination (i-j) pair to a network and from passenger travel to freight is straightforward: user benefits for each of the components may be added together to give the total user benefit for the network as a whole.

III.12 Note that technically, there is no unique attribution of user benefits between modes or indeed between i-j pairs, because it is not possible to identify an individual on the do-something network and trace back to find out what mode he/she used in the do-minimum. However, breaking down the total user benefit in proportion to the change in generalised cost on each mode is an intuitively appealing solution. This is effectively what happens when the rule-of-a-half is applied at the mode, or the i-j, level. In the disaggregated CBA results, user benefits should be presented split by mode, as well as by purpose (freight, working passenger, non-working passenger). The calculation of benefits by mode should be done by applying the rule of a half (ROH) separately for each mode.

Components of generalised cost

III.13 The components of generalised cost will vary by mode. Public transport users (bus, coach, train, air and ferry) will pay a money fare and give up time in order to travel to their destination. Car users and own-account freight users give up time, may be asked to pay an infrastructure access charge and pay for their own fuel and VOCs. Therefore there is a fundamental difference in the reported user benefits for users of different modes (see Table III.5).

Table III.5: Potential user benefit items by mode

Mode	Time	User charges	VOCs
Public transport modes	Yes	Yes	No
Car	Yes	Yes	Yes

III.14 Nevertheless, the components of generalised cost may be treated in the same way as modes, for the purpose of breaking down the total CBA result. Applying the RoH separately to the changes in each of these cost components can identify benefits by type of impact (time, VOCs or user charges). Hence formulae for time savings, VOC savings and benefits from lower user charges are as follows:

$$\text{RoH(time)} = \frac{1}{2}\left((H_0 - H_1) \times \text{VoT}\right)\left(T_0 + T_1\right)$$

Where H is the travel time per trip in hours, and VoT is the value of travel time in currency units per hour. The calculation of appropriate unit values for time is discussed in Annex IV. Subscripts for i, j, m and for different trip purposes (which would carry different values of time (see below)) have been omitted for simplicity.

$$\text{RoH(VOCs)} = \frac{1}{2}\left(\text{VOC}_0 - \text{VOC}_1\right)\left(T_0 + T_1\right)$$

Where VOC is the vehicle operating cost in currency units per trip. Subscripts for i, j, m and for different vehicle types (which would incur different vehicle operating costs (see below)) have been omitted for simplicity.

$$\text{RoH(user charges)} = \frac{1}{2}\left(U_0 - U_1\right)\left(T_0 + T_1\right)$$

Where U is the user charge in currency units per trip. Subscripts for i, j, m have been omitted for simplicity.

ANNEX IV – PRACTICAL APPROACH TO THE ASSESSMENT OF WIDER ECONOMIC IMPACTS

IV.1 BACKGROUND

IV.1.1 The evidence indicates that transport networks can play a key role in the economic development of countries and regions (SACTRA, 1999). This is part of the rationale for the Trans-European Network, and for the allocation of funds to transport investment, through ISPA and the International Financial Institutions (IFI's) (eg. EC, 2001; World Bank, 2001).

IV.1.2 At the project level, some practical steps can be taken to assess whether, and in what ways, improvements to a specific link in the network might contribute to economic development. These are outlined in Section IV.3.

IV.1.3 On a note of caution, however:

- Experience shows that it is very difficult to predict reliably the economic development responses to a specific transport investment project (SACTRA, 1999).
- The Transport Cost-Benefit Analysis already includes predicted gains in economic surplus to producers and consumers using the transport network: both for existing users and new users (see Section 4).
- In practice, introducing economic benefits measured *outside* the transport sector (such as changes in land values or GDP), is almost certain to introduce *double-counting* of benefits – that is, the same benefits seen from a different perspective and counted twice. This is why it is essential that any estimates of wider economic benefits are presented separately from the Transport CBA.

IV.1.4 The view taken by the IFI's and the European Commission is that a robust economic appraisal, at an overall international level, can be obtained through the Transport Cost Benefit Analysis (TCBA). Therefore it should be expected that the TCBA will receive a much greater weight than the 'wider economic impacts', in the decisions made by these organisations.

IV.1.5 On the other hand, the 'wider economic impacts' may be of particular interest to the local, regional and national governments of the country promoting a project. It follows that it is essential to establish who are the intended audience(s) for the appraisal – and their priorities - before deciding what share of the appraisal budget to allocate to 'wider economic impacts'. In general, when the appraisal is intended for the IFI's or ISPA, this share should be small, typically much less than 10%.

IV.2 What are Wider Economic Impacts?

IV.2.1 The potential wider economic impacts of transport investments include[4]:

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[4] This Section draws on the evidence gathered by the SACTRA committee for their report 'Transport and the Economy' (SACTRA, 1999).

- **role of the project in economic restructuring of regional and local economies.**
- **in industry - stimulus to local production / loss of local production.** Particular sectors may gain or lose, as a result of increased market access / increased competition.
- **in finance and commerce – stimulus to local business activity / loss of local business activity.**
- **stimulus to tourism / loss of tourism.** Inbound tourism may increase with improved access, whilst residents tend to travel further away for their vacations.
- **impact on the regional balance of payments.** Net impact on the value of exports minus imports.
- **in the labour market – stimulus to local employment / loss of local employment.** This may comprise the overall effect of the increased access and economic changes on employment, in relation to the population of working age.
- **in the land and property market – stimulus to new development / change in land use patterns.** This may include relocation of activity towards locations near to high-quality transport links and nodes. Possible implications for car dependency and sustainable development.

IV.2.2 These are 'wider' economic impacts in the sense that they are observed *outside* the transport sector: in other production sectors, or in the general labour market, or in the land and property market.

IV.2.3 Since they are caused by a change in the transport network, there will usually be a parallel change in benefits measured on the transport network – for example, an increase in exports will be reflected in an increase in surplus measured on the transport network that triggered the increase in exports. That will be measured within the Transport CBA.

IV.3 Steps in the Assessment of Wider Economic Impacts

Step 1: Review the objectives of the project

IV.3.1 The project objectives can be helpful, because they may help to point to particular types of economic impact which are expected from the project. For example, they may help to indicate which markets or industrial sectors are expected to benefit from the increase in accessibility, and in which localities/regions/countries. Taking an example from ISPA, the first stated objective of the Poznan rail modernisation project is "To eliminate a serious bottleneck (persistent mechanical breakdown, speed limit 60 km/h) on the whole E-20 line as part of the primary east-west trade route across Europe between Western Europe and [Warsaw, Minsk and Moscow]" (EC DG Regional Policy, 2002). It is suggested that the project objectives be recorded in the first row of a 'Wider Economic Impacts' table – like the one shown in Annex V (Table V.5).

Step 2: Review the local/regional economic context

IV.3.2 The wider economic impacts are likely to be influenced by background economic conditions and policies. For example, if economic development policies exist to promote growth in particular industries, the question should be considered: "to what extent does growth in this industry depend on implementation of this transport project"? It is important to consider not only whether the project is *necessary* for the economic development policy to succeed, but whether it is *sufficient*. In other words, will other facilities, inputs or incentives be needed to stimulate the industrial growth which is planned, and has that been budgeted for? When will the other measures be implemented?

IV.3.3 A key input to economic development is often a suitably-skilled pool of labour. This part of the assessment could focus on what skilled labour is available in the local/regional economy, how this labour is expected to be deployed as economic development takes place – and what are the transport needs of the new economic structure in the locality/region? How does the transport project contribute to these needs?

IV.3.4 A final example is natural resources. Are there distinctive natural resources within the locality/region and is it expected that these will be exploited/managed in the future? For example, do plans or opportunities exist for increased minerals extraction? Do plans or opportunities exist for improved management of major nature reserves and significant landscape or heritage attractions? How does the transport project contribute to any of this?

IV.3.5 Having considered this type of issue, a brief summary of the relevant background economic conditions and policies should be given (Table V.5), focusing on any industries or sectors where the project is expected to be contribute to the economic needs for expansion.

<u>Step 3: Define linkages through which the project is expected to impact on the economy</u>

IV.3.6 A very important step is to define clearly the linkages, or transmission mechanisms, through which the project is expected to impact on the local or regional economy in the medium-to-long term. This is likely to focus on how the key markets in the economy will adjust following any initial changes due to the project. For example, if the project is intended to facilitate trade with Western Europe (as in the Poznan example), how – specifically - will the industries of the candidate countries adapt/reorganise to take advantage of the improved trade route? What inward investment is expected? The impact should be traced through, step by step, from the reduction in transport costs to any predicted change in trade and economic performance.

IV.3.7 At this stage, negative impacts need to be considered too. For example, greater access to European markets is likely to lead to import substitution (in place of home-produced goods) in some sectors, leading to a loss of employment and transitional costs for workers and business.

IV.3.8 It has already been stated that analysis of these effects is very difficult. The effects are usually diffused through many different sectors of the economy, each of which is making its own decisions about production, location and marketing. Therefore an analysis of economic development impacts can require contact with a very large number of economic agents. These decisions are often made on a commercially confidential basis, so it can be difficult to ascertain market responses to transport change, even through careful market research. Another common problem is that the effect of one transport project alone will not change the network sufficiently to make an impact on business decisions.

IV.3.9 Bearing these difficulties in mind, it is worth considering whether a wider economic impact study will add much robust information to the project appraisal.

IV.3.10 If there is robust information to be reported, sources of evidence should be clearly stated (eg. ex post monitoring studies of comparable projects, where relevant). A summary of the linkages between the transport project and the economy should be given in Table V.5.

<u>Step 4: Assess the impact on key variables</u>

IV.3.11 Finally, the assessment should be brought to some conclusions – if possible, given the evidence – on the key variables which are of interest in the field of 'wider economic impact'. These typically include the following two, although other more specific indicators may be of interest (see Paragraph IV.2.1):

- Output, or Value-added (change in GDP by region);
- Employment (net change in Full-Time Equivalent employment by region).

IV.3.12 In most cases, the final results are likely to be qualitative, eg. an *increase* in local/regional employment is expected, particularly in specified industries. The results should be stated in Table V.5.

IV.3.13 If any quantitative results are presented, state which methodology has been used (see IV.4).

IV.3.14 For all results, refer to background studies and sources. It is also important to clearly state the study area – which region do the results apply to? This is important because the impacts may be reversed in other areas *outside* the study area.

IV.3.15 For further guidance on wider economic impacts, see SACTRA (1999) and Barrett (1999), both of which are available online via the world wide web.

IV.4: QUANTITATIVE ANALYSIS

IV.4.1 A key conclusion of recent research (SACTRA, 1999) is that there is no evidence of a standard 'multiplier' on Transport User Benefits, which could be used to estimate wider economic benefits. Instead there is reason to believe that the effect of transport infrastructure investment is context-specific. This means that there is a need to analyse each project separately, focusing on the specific circumstances - in particular:

- the *linkages* between transport and the regional economy (which markets are expected to be affected – housing? labour? goods and services? - through improvements in which types of transport – commuter transport? inter-city business travel? freight and logistics?);

- the *competitive advantage* of the regions connected by the improved transport link, in traded sectors (for example, competitive advantage may flow from natural resources and their role in agriculture, fishing, tourism or manufacturing, or it may flow from a regional pool of skilled labour with specific skills) – this will influence the changing pattern of employment and output as a result of the project.

IV.4.2 Forms of analysis which could be applied to gain an insight into the above issues, include the following:

- market research. This would be conducted primarily among employers (and potential employers) in the regions concerned, aiming to understand how the project will impact on their decisions about production, employment, location, and transport. For further information, see Barrett 1999. This form of analysis typically leads to qualitative statements about the likely effects of the projects based on the professional judgement of the analyst, and those who have been interviewed.

IV.4.3 There are three more formal modelling approaches, all of which are extremely demanding in terms of data availability, computing and cost. None of them are likely to be appropriate in a Central and Eastern European context, except in the case of network-level (rather than project-level) decisions. They are mentioned here only for completeness:

- Input – output modelling. This requires input- output matrices for the regions concerned, breaking down production into various economic sectors, one of which is transport. Changes to transport costs can be traced through the economic system to a set of changes in prices and output by sector. For further information, see SACTRA 1999. The key limitations of input-output analysis in this context are that many regions lack the requisite data but also that fixed technical coefficients do not allow for economies of scale and endogenous growth.

- Spatial computable general equilibrium (SCGE) modelling. This technique is at present experimental too and too expensive for most project appraisal applications. However, it offers the potential to estimate employment, output and welfare impacts in a whole economy setting. It is likely to be suitable entirely for major projects (say > $1bn). Development work is ongoing (Bröcker et al, 2001, Chapter 3).

- Land use – transport interaction (LUTI) modelling. Like SGGE, this is a heavily resource intensive modelling technique. Here, the focus is on interaction between the different markets – goods and devices, transport, land and property – in a detailed spatial framework. Generally LUTI models are more capable of appointing changes in employment and output between zones than of predicting overall gain in these variables. It is also worth cautioning that the effect of individual projects to these models has been found to be very small. For further information see Bröcker et al (2001), Chapter 2, and David Simmonds Consultancy (1999).

ANNEX V : EXAMPLE REPORTING TABLES

Table V.1: Project Definition

Nature of the problem (or opportunity) **Objective of the project** **Description of the project**
What alternatives were considered? (brief description including approximate investment cost) **i)** **ii)** **iii)** **Why were they rejected?** **i)** **ii)** **iii)**

Table V.2: Scenario Definition

Do-Minimum Scenario
Network description*:
Growth Assumptions (GDP and traffic):
Do-Something Scenario
Network description*:
Growth Assumptions (GDP and traffic)

Note: * state the assumptions made about: maintenance of the transport network; expected maintenance costs per annum; any network improvements changes relative to the current network. If it is assumed that certain other projects will definitely be implemented, this should be clearly stated here.

Table V.3: Cost-Benefit Analysis Results

Economic performance of the project		
Investment cost		□ million (€/US $/etc.)
Benefits net of operating costs over 30 years		□ million (€/US $/etc.)
Overall:		
in the Reference scenario		
IRR		□ %
NPV		□ million (€/US $/etc.)
BCR		□
in each alternative scenario tested		
IRR		□ %
NPV		□ million (€/US $/etc.)
BCR		□
(all compared with the do-minimum scenario)		
(all at base year prices and values)		
Financial performance of the project		
Organisation name		xxxxxx
Cash flow (+/-)	**Year 1**	□ million (€/US $/etc.)
	Year 2	□ million (€/US $/etc.)
	Year 3	□ million (€/US $/etc.)
	Year 4	□ million (€/US $/etc.)
	Year 5	□ million (€/US $/etc.)
	Year 10	□ million (€/US $/etc.)

TABLE V.4: DISAGGREGATED COST-BENEFIT ANALYSIS REPORTING TABLE

Impact	**Total present Value** base year Prices and Values		**Disaggregation by mode:**			
User Benefits and disbenefits						
Personal Travel			Car	Bus and Coach	Rail	Other
Travel Time						
Vehicle operating costs						
Safety						
User charges						
NET IMPACT		(a)				
Freight			Road Freight	Rail Freight	Other	
Travel time						
Vehicle operating Costs						
Safety						
User charges						
NET IMPACT		(b)				
NET USER BENEFIT (a)+(b)		(1)				
Private sector provider impacts			Road Infastructure	Bus and Coach	Rail	Other
Revenues						
Operating costs						
NET IMPACT		(2)				
Public sector provider impacts			Road Infastructure	Rail	Other	
Revenues						
Operating Costs						
NET IMPACT		(3)				
Investment costs			Road Infastructure	Bus and Coach	Rail	Other
Private sector						
Public sector						
Sub-TOTAL		(4)				
TOTAL						
Net Present Value NPV		(5)	= (1)+(2)+(3) +(4)			
Benefit:Cost Ratio, BCR		(6)	= (1)+(2)+(3)/-(4)			

Note: enter benefit and revenue gains as +; enter operating cost increases and investment costs as - items

ANNEX V.5

Table V.5: Reporting Wider Economic Impacts

Project objectives	• • • •
Background economic conditions	• • •
Key linkages	• • • • •
Wider economic impacts (positive and negative)	• • • • •

ANNEX VI – VALUES FOR TIME AND SAFETY

VI.1 Time and safety in transport project appraisal

VI.1.1 Investment projects which improve the transport infrastructure typically lead to savings in *travel time* (due to more direct routes and higher speeds) and reductions in the numbers of *accidents and casualties* (due to safer design standards) relative to the situation without the project – the do-minimum scenario. Values for travel time and safety are not generally available in the form of market prices because these are not traded commodities in their own right. Therefore an alternative basis is needed for valuing time and safety in project appraisal. The theoretical basis – again, a microeconomic one – is explained in the texts listed in the References at the end of this paper. Practical advice on these matters is given below, with further references on specific issues that it has not been possible to cover in depth here.

VI.2 Values for time savings

VI.2.1 The money value of travel time savings (VoT) is one of the most important variables in transport infrastructure CBA. Savings in travel time typically form a very large proportion of the total project benefits – figures from the past experience of various national governments within the EU15 and the EIB suggest that 80% is quite typical . Therefore:

i) care is needed in determining values of time;

ii) where there is uncertainty about the appropriate value, it makes sense to carry out sensitivity tests on the overall CBA results in order to ascertain the impact of changing the VoT; and

iii) to maintain consistency in appraisal, it is <u>essential</u> that consistent values of time are used across the pool of projects being compared (for example, TINA projects within a particular country).

VI.2.2 When infrastructure is improved, time savings typically arise for both personal travel and freight movement. Within personal travel, there is a clear distinction (in terms of VoT) between trips made whilst working and trips made for other purposes. Working time includes trips either on an employer's business or on own business for those who are self-employed. Non-working time includes all other types of trip, notably commuting (travelling to a regular workplace), leisure and education. In general, therefore, values will be required for:

- savings in working time (euros per person hour);
- savings in non-working time (euros per person hour);
- savings in freight time (euros per vehicle hour).

VI.2.3 In transport project appraisal, values of time should wherever possible be based on local values. Ideally, local values would be derived from local (or at least regional or national) data and survey evidence within the transport market and would reflect individual users' willingness-to-pay for time savings. Existing ‘value of time’ studies within the EU15 can be referred to as a guide to best practice, including in particular MVA/ITS/TSU (1987).

VI.2.4 However, where is it not possible to obtain reliable willingness-to-pay based values, the following rules of thumb should be adopted (Box VI.1).

Box VI.1: Rules of thumb for the value of travel time savings

Values for working time should be set equal to the average gross wage rate in the country where the trip originated. The gross wage rate is defined as the cost to an employer of one hour of an employer’s time, including any income taxes, pensions, social security contributions and other employee-related overheads. It is implicitly assumed that no part of the employee’s travel time can be used productively, and that when travel times fall the employer is able to reorganise their business to make full use of the additional time for which the employee is available. Clearly both of these are simplistic assumptions, but first may often be true, particularly for travel by car, the second is more likely to true in the long run given time for adjustment.

Hourly gross wage data for countries may be available from national statistics. If not, it will be necessary to infer an hourly wage from national/regional annual income data. Assumptions will then be needed on the size of the working population and the number of hours worked per annum – these should be made explicit when the appraisal is reported.

Where a case can be made that the values of time of users of a particular mode are higher (or lower) than the average gross wage, mode specific adjustments to the value of time would be acceptable. The rule of thumb here is that domestic air travellers’ working time may be valued at 2.5 time car users’ values (based on EIB, 1996). International air travellers’ working time should be valued at the rated quoted in EUNET, uprated to current year values.

Values for non-working time should be set at 30% of the average net wage in the country where the trip originated. Net wages are defined as take home pay after any income taxes, pensions, social security contributions and other employee-related overheads have been deducted. Where it is not believed that the whole working population can afford to travel, an attempt should be made to identify the gross wage of the travelling population.

Values for air travel in non-working time may be set at 0.85 times the working time value for car travel (again, based on EIB, 1996).

VI.2.5 The relevance of VoTs for the country in which the trip originated is that we assume VoT goes with the individual not with the part of the world they are travelling through. International traffic originating in the EU15 will have a substantially higher VoT, thus:

a) it is vital to separate international traffic in the traffic forecasts which form inputs to the CBA;

b) separate calculations are clearly required for international and domestic traffic using appropriate values. Values for the EU15 available in EUNET Deliverable D9 (Nellthorp, Bristow and Mackie, 1998).

VI.2.6 Values of time will be in year 2000 euros and in the resource cost unit of account. Possible sources of local values include previous project appraisals or demand studies, or specific value of time research – however, in all cases consider carefully whether values are transferable between studies.

VI.3 Using values of time in CBA

VI.3.1 Note that for a minority of trips, changes in the transport network may lead to slight increases in travel time. In such cases, the same value should be applied to increases in travel time as to travel time savings. Provided that the rule of a half formula is being used to estimate the user benefits, no changes will be needed to the appraisal procedure.

VI.3.2 The above rules of thumb relate specifically to in-vehicle time (IVT). For other aspects of personal travel time, including time spent walking, waiting or interchanging between modes, the evidence is that time spent in these activities may be valued differently. Based on the latest review evidence (Wardman, 1998), it is recommended that the value used should be 1.6 times the value for in-vehicle time, although this rule of thumb could also be replaced by local research under the 'pure willingness-to-pay' approach.

VI.3.3 Note that there is an appraisal tradition in Germany that the money benefits of non-working time savings are scaled-down to allow for 'misperception' by individuals of small time savings. It is possible that this practice may also be found in Central Europe or Cyprus, or the CIS countries, however for both theoretical and practical reasons (Nellthorp, Mackie and Bristow, 1998), it is recommended that in transport infrastructure appraisals, large and small time savings should be valued equally.

VI.3.4 Finally, note that values for own-account freight time will include the driver's time, since in that specific case, personnel costs will not be included in VOCs.

VI.4 Values for safety improvements

VI.4.1 In order to provide a consistent set of values for safety impacts, definitions are needed for: casualty severities; accident severities; and the various components of costs associated with them. The definitions adopted by EUNET are shown in Box VI.2. The corresponding measures are: for accident-related costs, euro per accident; and for casualty-related costs, euro per casualty. Accident related costs and casualty related costs should be added together to obtain the total costs of accidents on the network.

Box VI.2: Safety impact definitions

Casualty severities:

- 'fatality' – death within 30 days for causes arising out of the accident;
- 'serious injury' – casualties who require hospital treatment and have lasting injuries, but who do not die within the recording period for a fatality;
- 'slight injury' – casualties whose injuries do not require hospital treatment or, if they do, the effects of the injuries quickly subside.

Accident severities:

A 'damage-only' accident is one in which there are no casualties. A 'fatal' accident is one in which there is at least one fatality. A 'serious' accident is one in which there is at least one serious casualty but no fatalities. A 'slight' accident is one in which there is at least one slight casualty but no serious injuries and no fatalities.

Accident-related costs:

- material damage
- police and fire services
- insurance administration
- legal and court costs

Casualty-related costs:

- medical and healthcare costs incl. Administration
- lost output
- human costs – pain, grief and suffering.

The total appraisal value of an accident is the sum of the accident-related and casualty-related costs.

Source: EUNET Deliverable D9 (Nellthorp, Mackie and Bristow, 1998)

VI.4.2 The variation among values for safety impacts within the European Union 15 is very wide: from 352000 euro per fatal casualty in Portugal (at 1995 prices and values) to 1660000 euro in Sweden. A similar degree of variation may be expected in other countries. However, in the absence of locally-based values for safety, the following rules of thumb should be applied, as factors to be multiplied by the value of working time per person hour (car) for the country concerned.

Table VI.1: Appraisal values of safety – factors on value of working time

<table>
<tr><td>Casualty severity</td><td colspan="2">Value per casualty avoided</td></tr>
<tr><td>Fatal</td><td colspan="2">* 43000</td></tr>
<tr><td>Serious</td><td colspan="2">* 5100</td></tr>
<tr><td>Slight</td><td colspan="2">* 400</td></tr>
<tr><td>Accident severity</td><td colspan="2">Value per accident avoided</td></tr>
<tr><td></td><td>Road</td><td>Rail</td></tr>
<tr><td>Fatal</td><td>* 740</td><td rowspan="3">Injury accidents: *1500</td></tr>
<tr><td>Serious</td><td>*490</td></tr>
<tr><td>Slight</td><td>*450</td></tr>
<tr><td>Damage only</td><td>*101</td><td>* 500</td></tr>
</table>

Source: based on EUNET (Nellthorp, Bristow and Mackie, 1998)

VI.5 Using values of safety in CBA

VI.5.1 The numbers of accidents on the do-something and do-minimum networks within the study area should be estimated using national or local data on accident rates and trends. Changes in infrastructure types and transport mode shares should also be taken into account when estimating the quantitative change in number and severity of accidents and casualties.

VI.5.2 The same value should be applied to any deterioration in safety as to safety improvements, so for appraisal purposes, one can work out the net change in safety and apply the unit values to that.

VI.6 Growth in values of time and safety over time

VI.6.1 Values of time and safety should be increased (in real terms) over time. Current advice is that this should be indirect proportion to the growth in GDP per capita.

ANNEX VII – Common Errors in Application of CBA for Transport Projects[5/]

Twenty-one sources of error and bias in transport project appraisal

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Abstract

Twenty-one sources of error and bias in the appraisal of transport projects are identified. These relate to objectives, definitions, data, models and evaluation conventions. Objectives may be unclear, incompletely specified or inconsistent with appraisal criteria. Definitions of study areas and scheme options for testing may bias the outcome. There are multifarious sources of data and model error. Double counting, inappropriate values, and failure to balance quantified and non-quantified items can all affect the evaluation. We suggest that there is a systematic tendency to a mega-error—that of appraisal optimism. Three antidotes to this condition are briefly suggested.

1. Introduction

Recently, critical reviews have been provided of the applications of cost–benefit analysis to transport projects in Britain (Nash, 1993) and to a wide range of investment projects in developing countries (Little and Mirlees, 1994). In this paper, we add to this literature by listing various sources of error and bias in the appraisal of transport projects, particularly with respect to British experience. Our purpose is not to argue that appraisal is so prone to bias as to be a worthless exercise, quite the reverse. The message is that appraisal cannot be a black box; critical judgement is required to probe the strength of every link in the chain of logic. This short paper is intended to raise the consciousness of some common pitfalls in the hope that these can be recognised and avoided. The points are loosely grouped from the more strategic to the more tactical, but this implies nothing about their relative importance which will anyway be context-specific.

2. Unclear objectives or conflicts between stated and actual objectives

Ideally, objectives should be clear and appraisal criteria should follow directly from them. In practice, conflicts can easily arise. Railtrack may be required to invest in safety enhancement even if this has a negative commercial return, with unclear implications for the appraisal criteria. Mega projects, e.g. Crossrail or the Channel Tunnel Rail Link may take on a life of their own; it may be unclear what appraisal criteria are to be used and why. Lack of shared objectives between partners in major projects may also lead to appraisal problems.

An example is provided by the leaked Department of Transport memo on the criteria for ranking the roads programme (Local Transport Today, 1996a). From this it appears that roads are not appraised solely on the basis of their traffic, economic and environmental performance as expressed in the Framework, but also on Government Office judgement and their importance to the overall network. Furthermore, separate cut-offs apply to projects in the core motorway programme and the more peripheral parts of the trunk road network, reflecting the need to spread expenditure more widely than a strict cost–benefit analysis approach might imply. Remarkably similar issues seem to arise in Swedish road planning (Nilsson, 1991).

3. Prior political commitment

Schemes may be difficult to reject because of the degree of political commitment they have accumulated. The Humber Bridge might be the best example in the UK. The message here is that outline appraisal needs to come sufficiently early in the project cycle for graceful withdrawal to be possible, and that commitment should not be given in a form which makes it impossible to withdraw at a later stage. Note that 'political' covers not only the commitment of politicians, but also of scheme promoters. This point makes a strong case for open-independent scrutiny of appraisals.

4. Current transport situation not accurately known

The start of any appraisal is to collect data on the existing

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PII: S0967-070X(98)00004-3

[5/] The article by P. Mackie and R. Preston is the reprint from Transport Policy, 5 (1998) –7, Elsevier Science Ltd., 1998 travel situation. A number of problems are encountered:

1. Although road traffic flows can be relatively easily measured, precise origins and destinations are more difficult to obtain;
2. Data on bus and rail usage are commercially confidential. Surveys can be easily undertaken but suffer from a number of problems. For example:
3. Roadside/on-vehicle/at station surveys are usually undertaken on a 'typical' day in the spring or autumn. An annualisation factor is then applied to get yearly data. The problem is that there is no such thing as a 'typical' day. There may be a tendency to choose 'atypical' days where transport demand is at its greatest
4. Household surveys, particularly if they are self-completed, may be dominated by households (and days) in which a lot of travel is undertaken.

Because data are so costly to collect, studies are often based on data collected many years ago. The origin/destination matrices are then updated so that overall flows are consistent with those observed. However, this updating method fails to pick up changes in the pattern of flows.

5. The study area is incorrectly defined

This is believed to be a common source of error in road appraisal. For budgetary reasons relating to data collection and modelling costs, the study area may be quite tightly defined. This risks knock-on effects outside the study area and wide-area traffic reassignment being inadequately handled. It is believed that one of the sources of error in the M25 traffic forecasts was the underestimation of longer-distance rerouting effects.

A similar problem has been encountered in forecasting the demand for new stations. A radius of 2 km has often been used to define the study area. However, this radius may be too great for sites with poor levels of service, particularly if there are nearby stations with better levels of service. By contrast, this radius may be too small for new stations with good levels of service, particularly if bus feeders, and park and ride facilities are envisaged (Preston, 1987).

6. Incorrect definition of the base and do-something cases

In most cases, the base case will not be a simple 'do-nothing' scenario, but a 'do-minimum' scenario. For example, without the major modernisation of the West Coast Mainline, considerable investment in renewals and expenditure on maintenance would still be required in order to maintain current levels of service. Alternatively, if 'do-nothing' means continue to spend on renewals and maintenance that which have been spent on in recent years, it is likely that train services would suffer from reduced speeds, increased late running, deteriorating ride quality, etc. which would have impacts on demand, and on user and non-user benefits. 'Do-nothing' would really mean 'do-worse'. A plausible baseline case is essential to the realism of the appraisal. Another source of error is the omission of some do-something options, especially low-cost alternatives. For example, investments in guided bus and, indeed, conventional buses are rarely compared to investment in light rapid transit. Where comparisons are made they may not be fair. For example, light rapid transit has segregated right of way, conventional bus does not (or, if it does it is achieved at the expense of other road traffic). Similarly, light rapid transit and guided bus schemes may follow exactly the same route, thus negating the guided bus's advantages in terms of flexibility and reduced need for interchange. In road schemes, junction improvements and improved maintenance tend to get neglected at the expense of new road building (especially by-passes).

7. Gold plating of the 'do-something' option/cost over-runs

The option that is chosen may be over-engineered, either at the time or subsequently. Examples include the provision of excess capacity and, more contentiously, 'over-provision' for disabled access and for safety and security. The latter are believed to be one of the main causes for the cost over-runs on the Channel Tunnel, with out-turn costs, at £10 billion, being double those forecast (Szymanski, 1995). A more common cause of cost over-runs relates to engineering problems which result in construction costs being underestimated. Both the Humber Bridge and the Channel Tunnel were adversely affected by geological problems. Such problems may lead to over-runs in the construction period and delays in achieving full service. This is particularly important to Private Finance Initiative (PFI) projects given the high rate of discount.

8. Errors in planning assumptions

Many schemes may be dependent on planning decisions. For example, the M65 was built on the assumption that Central Lancashire New Town would be fully developed. Concorde was developed under the assumption that supersonic flights would be granted access to inland air space throughout the world. One of the problems with the Sheffield Supertram is that a housing scheme it was designed to serve has been demolished. This was due to long planning timescales. The data used to forecast Supertram demand were nine years old by the time the system opened (Local Transport Today, 1996b). As a result, the overall size of the public transport market in the corridors served was overestimated and initial out-turn demand was 8 million passengers per annum, compared to a forecast of 22 million.

9. External factors incorrectly forecast

Most transport forecasts are in turn dependent on forecast of external factors, e.g. population, income, economic activity and car ownership (which ought to be an internal factor but is usually measured exogenously). These are rarely forecast accurately, particularly for schemes with long planning periods and long project lives. For example, the shortfall in forecast demand for the Tyne and Wear Metro (opened in the late 1970s/early 1980s) was attributed to being based on over-optimistic forecasts of living standards and hence the propensity to travel on Tyneside, which had their origins in studies undertaken in the 1960s (Fullerton and Openshaw, 1985).

10. Transport inputs incorrect

This may result when travel speeds, service frequencies and fares are not as forecast. For example, Sheffield Supertram was forecast to have a speed advantage over rival bus services. However, due to junction delays and route variations, these speed advantages have not materialised. When public transport infrastructure is being provided, a particular problem is in determining the frequency of service, speed of the services, other service quality attributes and the fares that operators will introduce (see, e.g. Nash, 1992).

11. Model error

The models used to forecast the impact of transport investments may contain substantial error. Apart from measurement error (discussed above), common sources of error include:

1. Specification error. The models used may fail to take into account the impact of key explanatory variables, e.g. income or may mis-specify the effect of an explanatory variable (e.g. the elasticities have been wrongly measured). The use of global averages (e.g. a price elasticity of −0.3) may be particularly misleading.
2. Lack of transferability. A model successfully developed in one area at a certain point of time may not be transferable to another area and/or another point of time.
3. Aggregation error. Models, e.g. the logit, are often calibrated with disaggregate data but applied with aggregate data. This will lead to bias as the average of a set of non-linear functions will not be the same as a non-linear function of a set of averages (Westin, 1974).
4. The scale factor problem. Models based on stated preference data and the logit model may be affected by this technical problem (see Bates, 1988). The upshot of this is that although relative valuations will be unbiased, forecasts are likely to be biased.

These errors will not be a problem if they are random, as they will cancel out and there may be a trade-off between measurement and specification error, with the former increasing and the latter decreasing as model complexity increases (Alonso, 1968). However, these errors will be a problem if they are systematically in one direction or another. In practice, model errors are difficult to detect as they are often swamped by input data errors (see Sections 4 and 5, Sections 9 and 10 above).

12. Interactions not taken into account

Many transport investments will have effects on rival transport markets. The response of these operators will be difficult to forecast. One of the features of the Sheffield Supertram has been the vigorous competition from the rival bus companies which was not envisaged at the planning stage. Similarly, it seems that the Eurotunnel failed to anticipate the degree of competition it would face from rival ferry companies. Many studies of light rapid transit systems fail to take into account the impact of re-congestion on the road network, despite evidence that around 35% of those who are initially forecast to switch from road to rapid transit will switch back (HFA, 1991, Preston, 1994). A particular problem for even major public transport schemes is that the effects on the parallel road network are likely to be marginal and temporary, and hence difficult to measure (Younes, 1995).

There may also be important interactions within the transport market served by a transport investment. A new road may initially reduce congestion on parallel roads, but the reduced journey times on the parallel roads will attract traffic back from the new road (this is usually taken into account) and attract brand new traffic (induced demand—which until recently has not been taken into account) [see Coombe, 1996]]. The release of latent road traffic demand is believed to be one of the dominant features of the M25. Similarly, an upgrade of a rail line (e.g. the West Coast Main line) would need to take into account the reaction of rival operators on other lines (e.g. on the East Coast Main line for London–Glasgow traffic or on the Chiltern line for London–Birmingham traffic).

13. Dynamics not taken into account

There are a number of issues here. Firstly, disruption may have important effects. For example, it was forecast that all suburban railway users would transfer to the replacement Manchester Metrolink service. In the event, only around three-quarters did so. This was believed to be due to the fact that the suburban rail service was suspended for over a year whilst the Metrolink was being built. Some rail users found alternatives which they continued to use after the Metrolink was opened (Vaughan and Gane, 1994).

Secondly, any new product may be expected to build up demand over time. This is referred to as the product take-off curve. This is often neglected. For example, for new stations in West Yorkshire, ex-post evaluation found that it took demand up to five years to reach its equilibrium levels, with demand in year 1 only being 57% of that in year 5 (Preston, 1987). Such a learning curve is particularly important to include in PFI projects, as relatively high interest rates will discount benefits in future years.

Thirdly, where new technology is introduced, the 'bath-tub' effect is often ignored. This phenomenon describes the effect of unreliability over time. Initially, this is high as the technology exhibits teething problems. However, over time, unreliability rapidly decreases only to rise gently over time as the asset wears out (Godward, 1992). It is likely that the appraisal of Eurostar rail services did not take this into account.

14. Project life incorrectly assessed

Project lives are usually based on the expected technical life of the asset. In some cases, these may be misjudged. The 50 year project life used to assess the Victoria line now looks excessive. However, given discounting, extensions of project lives from say 30–50 years are unlikely to have a major impact on appraisal. More problematic is where the economic or market life of a product is substantially less than the technical life of the project. An example of the former is the investment in steam locomotives in the British Rail modernisation plan of the 1950s whose economic lives were cut short by advances in diesel and electric locomotion technology. An example of the latter is the Bradford Interchange. There was a demand for this facility as a bus station and depot, whilst the bus industry was publicly owned and controlled. The reforms of the bus industry following the 1985 Transport Act effectively took away the market for this facility.

15. Quantifiable impacts omitted

In some instances, impacts which could easily be quantified are excluded from the analysis. For example, the disruption effects in terms of congestion, loss of business, etc. of the construction of the Sheffield Supertram were not included in the scheme appraisal, nor was the loss of goodwill towards the scheme that the disruption caused (although this is more difficult to measure). Similarly, walking times were omitted from the appraisal of the Bradford Interchange, even though these were likely to increase as a result of the scheme. Perhaps the most obvious example of a quantifiable impact being excluded is the exclusion of user benefits in urban rail appraisal in the UK (see, e.g. Nash and Preston, 1991). This policy seems likely to be continued by the Office of Passenger Rail Franchising (OPRAF, 1996).

16. Treatment of non-quantifiable impacts

One of the main criticisms of cost–benefit analysis is that impacts which are difficult to evaluate in money terms are excluded. However, this may be addressed by using qualitative approaches (often politically driven) to take these impacts into account. The problem of what Mishan (1988)] calls 'horse and rabbit stew' then occurs. If you take one horse and one rabbit, no matter how you combine them the taste of horse dominates the stew. Similarly, if you take one set of quantifiable impacts and one set of non-quantifiable impacts in an appraisal, one set may dominate. Examples include the Channel Tunnel rail link where conventional cost–benefit analysis favoured the south London route, but where environmental and economic developmental (and political) factors favoured the east London route. Similarly, although conventional cost–benefit analysis in the 1960s indicated that rail lines, e.g. the Cambrian Coast line, should be closed, non-quantifiable factors, e.g. developmental factors and non-use values (particularly existence values), ensured that no such decision was taken. Conversely, it is often argued that road projects depend excessively on the quantified COBA (the Department of Transport's Cost–Benefit Analysis computer program) results with inadequate weight being given to the environmental impacts. What we are arguing is that the problem is not so much with including non-quantifiable impacts, but in assessing their relative importance vis-à-vis quantifiable impacts. Multi-criteria analysis may assist in this respect.

17. Incorrect values used

Although the impacts of a scheme may be correctly appraised, their valuation may remain controversial. In terms of values of time, controversies still exist regarding the use of equity or behavioural values, or some mix of the two, the split between working and non-working time (and, in particular, the latter's division between commuting and other non-work time), and the treatment of small time savings. In terms of the value of life, the main debate is between the use of lost output or willingness to pay approaches, or some combination of the two. Similarly, in terms of environmental valuation, the main controversy revolves around the use of standards driven or willingness to pay approaches. Possibly the classic example of the use of wrong values was in the third London Airport inquiry when the Norman Church at Cublington was valued by its fire insurance value, creating a focus for derision of the entire Cost–Benefit Analysis approach (Self, 1970).

18. Double counting

There is a possibility that certain impacts may be included twice or possibly three times in an appraisal. For example, the primary impact of a transport scheme may be the reduction in travel times. The secondary impact is improved accessibility to work, schools, shops and leisure facilities. The tertiary impact is the increased economic activity that the transport scheme has promoted. Provided generated travel has been correctly forecast, all of the secondary impacts and most of the tertiary impacts are merely downstream manifestations of the primary impact. Those tertiary impacts that are not directly related to primary impacts may be related to a multiplier effect. This may be considered a transfer in that a similar investment elsewhere would have a similar multiplier effect.

19. Transfers

These need to be correctly identified. Examples of transfers which are often not identified include taxes, grants and subsidies, revenue, reductions in wage rates (a gain to employers, a loss to employees) and increases in property prices (a gain to property sellers but a loss to property buyers) [Mohring, 1993]]. Employment effects may often reflect transfers of jobs from one area to another rather than net gains. This may depend on the definition of the study area (see Section 5). From a national perspective, if the East–West Crossrail scheme linking London's Liverpool Street and Paddington stations helps to attract jobs to the City of London which otherwise would have gone to Paris or Frankfurt, this is a net benefit. From a European perspective, this is a transfer with zero benefit. Trans-boundary projects, e.g. the Paris–Brussels–Amsterdam high speed rail line often encounter problems of this kind.

20. Treatment of systems effects

An example of this is where a series of by-passes are appraised in isolation from each other. However, collectively they may represent a major upgrade of a trunk road, but the re-routed (and generated) traffic that the trunk route attracts is not taken into account in the individual by-pass appraisals. The appraisal of schemes on the A65 and A650 Leeds/Bradford–Skipton–Kendal route is a relevant case. Another example concerns airport planning. Typically, airport development plans are made in isolation from each other, that is assuming the attractiveness of other airports in the system remains constant. An improvement at airport A may be partly justified by the diversion of traffic from airport B, but the economic effects on B are not considered in the appraisal. This may be further compounded if airport B is also contemplating expansion. There has been some concern that Liverpool and Manchester airports are in this situation.

Conversely, some infrastructure may be built in anticipation of a systems effect that does not materialise. For example, one of the reasons for the low traffic levels on the Humber Bridge is that it is not connected to the motorway network. Indeed, the existence of the Humber Bridge was one of the driving forces behind the call for an East Coast motorway.

21. Rules change during the planning period

An example is the Manchester Metrolink (see Table 1). This in turn relates to the long planning periods for major transport infrastructure (see also Sections 8 and 9). In the case of the Manchester Metrolink scheme, the planning period is some 10 years, whilst the concept of a Picc–Vic link in Manchester has a planning history of some 100 years. As a result of these long planning periods, transport schemes are vulnerable to political, financial and economic risk including changes in the appraisal criteria in the middle of the planning process. The Birmingham Northern Relief Road has also been affected by rule changes concerning the financial and funding environment.

22. Appraisal optimism

This is arguably the greatest problem of all and has been well documented by [Walmsley and Pickett (1992)], and Pickrell (1989)], particularly for urban rail. It stems from benefits being overestimated and costs underestimated. Looking at the 20 problems we have already identified, we believe the following may contribute:

1. Prior political commitment (Section 3);
2. Overestimates of existing travel volumes (Section 4);
3. Full range of low cost 'do-something else' options omitted; performance of base case unrealistically poor (Section 6);
4. Subsequent gold plating of the 'do-something' option (Section 7);
5. Overestimate of population and economic growth (Section 9);
6. Overestimate of the performance of the new transport facility, particularly in terms of speed (Section 10);
7. Underestimate of the reaction of rival transport operators and infrastructure owners (Section 12);
8. Failure to take into account the slow build-up in demand (Section 13);
9. Asset lives overestimated (Section 14);
10. Quantifiable costs excluded (Section 15);
11. High valuations attached to scheme benefits (Section 17);
12. Benefits counted twice or even three times in different parts of the appraisal (Section 18).

It is our judgement that these 12 problems tend to act systematically so as to promote appraisal optimism. The eight other problems, in our judgement, are less likely to act systematically to promote appraisal optimism:

1. Unclear objectives may help promote or reduce the prospects of a scheme going ahead (Section 2);
2. If the study area is defined too tightly, this may reduce forecast net benefits (e.g. park and ride schemes) or increase them (M25 —recongestion effects not taken into account) (Section 5);
3. Planning bias may arise due to developments that were expected to take place but did not happen (e.g. Central Lancashire New Town) or were not expected to take place but did (e.g. commercial development around the M25) (Section 8);
4. Model error may lead to under- or over-estimates of impacts (Section 11);
5. Problems with transfers most commonly occur when an impact is treated as a net benefit but is in fact a transfer. However, in some cases a net benefit may be treated mistakenly as a transfer [as occurred with rail revenue from non-bus users in the Cambrian Coast line closure study (Section 19), Sugden, 1972]];
6. Omission of non-quantifiable impacts (Section 16) and systems effects (Section 20) may go either way;
7. Rule changes during the planning period may increase or reduce the chances of a scheme going ahead, with the latter being the more common (Section 21).

23. Conclusion

The above checklist suggests to us that appraisal optimism is the greatest danger in transport investment analysis. Appraisal optimism happens because the information contained in the appraisal tends to be owned by scheme promoters who have obvious incentives to bias the appraisal—deliberately or unwittingly—in one or more of the ways described above. This is a particularly acute problem if the scheme is in the public rather than private sector, since the normal commercial checks and balances on excessive optimism do not apply.

We can suggest three antidotes. The first is to have within-organisations, groups whose function it is to own the appraisal regime rather than the projects, and to ensure that the appraisal is honest. The second is to expose projects to open scrutiny at public inquiries, with adequate resources available to cross-examine the scheme promoters. The third is to spend a lot more on ex-post evaluation than is currently done. Systematic checking of what actually happened relative to forecast is an important discipline.

Acknowledgements

This paper was inspired by a short course on 'Transport Investment Analysis' run at the University of Leeds in February 1997. We would like to thank the students and our teaching colleagues (Professors Chris Nash, Alan Pearman and Nigel Smith) for their inputs to that course. Any errors or mistaken conclusions are, of course, our own.

Table 1
Evaluation of marginal costs and benefits of LRT compared to existing public transport (£ million, discounted 30 year values)

	1984	1987	Tyson
Capital costs	26.31	28.20	45.56
Operating costs	− 5.55	− 5.61	− 38.29
User benefits	25.52	29.80	
Revenue	6.93	7.62	
Non-user benefits			8.00
Benefit:cost ratio	1.44	1.53	1.01

Appendix A. Changing rules during the planning period: an illustration

The Metrolink scheme underwent two evaluations related to grant submissions in 1985 and 1987 (GMPTE, 1985] GMPTE, 1987). These are shown in Table 1, along with a later, unpublished, evaluation undertaken by Bill Tyson.

The 1984 and 1987 submissions were broadly similar, although the latter had more adequately taken into account the effects of bus deregulation. Both give a benefit:cost ratio of around 1.5. The main benefit is that of time savings to users of the Metrolink. However, new government funding rules meant that such user benefits can not be taken into account (Department of Transport, 1989). In Tyson's evaluation, user benefits are excluded, as are rail operating costs and revenues, presumably on the basis that revenues and costs will be perfectly matched. In Tyson's evaluation, the main benefit is the reduction in subsidy due to withdrawal of Section 20 support for the Bury and Altrincham rail lines, equivalent to £36.98 million over 30 years (the remaining £1.31 million of operating cost savings are due to withdrawal of tendered bus services). The other main benefits are non-user benefits, of which £6 million are due to congestion relief and £2 million due to accident reductions. Under these new evaluation rules, the Metrolink scheme just has a benefit:cost ratio greater than unity. It is noticeable that non-user benefits are estimated as only being around 30% of user benefits. It also seems likely that a large element of user benefits has been captured as revenue in the Tyson evaluation, largely as the result of higher peak fares.

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