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# Transport appraisal revisited

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*Abstract*
Cost-benefit analysis has become a widely used and well developed tool for evaluation of suggested transport projects. This paper presents our view of the role and position of CBA in a transport planning process, partly based on a brief survey of a number of countries where CBA plays a formalised role in decision making. The survey shows that methodologies, valuations and areas of application are broadly similar across countries. All countries place the CBA results in a comprehensive assessment framework that also includes various types of non-monetised benefits. An important advantage with using CBA is that it is a way to overcome cognitive, structural and process-related limitations and biases in decision making. Some of the main challenges to CBA and to quantitative assessment in general lie in the institutional and political context. There is often a risk that CBA enters the planning process too late to play any meaningful role. This risk seems to increase when planning processes are centred around a perceived "problem". If the problem is perceived as important enough, even inefficient solutions may be viewed as better than nothing, despite that the definition of what constitutes a "problem" is often arbitrary.

*Keywords*: Cost-benefit analysis, project appraisal, transport investments.
*JEL Codes*: H43, R42, R48.

# 1 INTRODUCTION

Democratic societies face considerable difficulties in deciding what to do about transport. On one side of a triangle there is a firm belief, with some evidence, that transport investment is an important driver of economic performance and competitive advantage in an open globalised marketplace. On a second side are those who say that our lifestyles are unsustainable and that meeting demand growth or creating new demand for travel is fundamentally misguided. Completing the triangle is a sceptical public who would like better transport infrastructure, but not at any cost, and certainly not in their own back yard. Whereas fifty years ago, transport decision making was in the hands of a professional elite, overseen by elected politicians, today we have moved closer to decision by democratic consent, with all the pros and cons of the Athenian form of governance which that entails.

Many excellent texts have been written about economic appraisal methods (for example Boardman et al (2011)), but given this culture change, the purpose of this paper is to address some particular questions about transport appraisal. Where does appraisal sit in the overall decision-making process? What is the state of the art of transport cost-benefit analysis in particular? What are the key challenges facing practitioners? Is the transport appraisal framework which is widely taught in universities around the world still a useful paradigm, or is it buckling under the strain of divergent social forces and visions?

We first summarise why and how CBA is used, and give our view of its main benefits (section 2). We then compare methodologies and uses across seven countries where CBA is broadly used, noting many similarities but also some differences (section 3). CBA is faced with both technical and institutional challenges, and we summarise what we believe are the most important ones (section 4).

# 2 THE ROLE OF CBA

## 2.1 The Role of Transport Appraisal

The creation, assessment and approval of a transport project is a dynamic process with multiple feedbacks within a forcefield of influences which can be roughly grouped into the fields of vision, pressures and analysis (Figure 1). Stripping the process right down, somebody somewhere has an idea. That idea then enters an arena of pressure testing, at first at the outline level and then at successively more detailed levels. The idea might be seen as consistent with policy or political aspiration, it might gel with popular opinion, it might be seen as addressing particular problems. But then come the tough questions: what will it cost, who will pay, can it be delivered and above all, is it worthwhile?

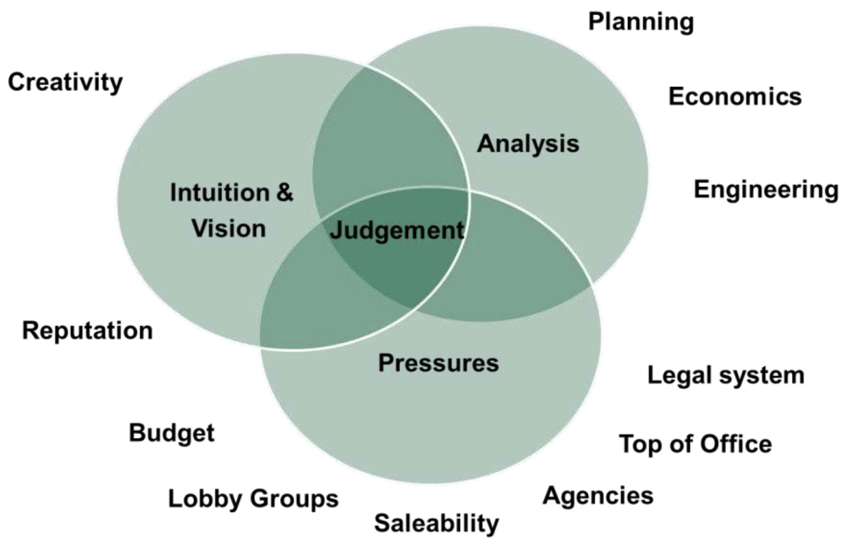


***Figure 1. Decisions and judgements are affected by visions, pressures and analyses.***

Once it is accepted that these decisions need to be addressed as part of the process, we enter the analysis territory of Figure 1, and specifically the transport modelling and appraisal regime. The results feed back into the melting pot of decision making referred to in Figure 1 as Judgement.

There is such a thing as human frailty. Judgement can be susceptible to such factors as whose idea it was in the first place (not invented here), where it is, who wants it, who will benefit and pay, and how much political capital will need to be spent to see it through. Such considerations inevitably enter into the judgement calculation. However this very frailty, or perhaps realpolitik, makes an argument for a strong appraisal framework with rules, established independently of individual cases and capable of being applied repeatedly over time so as to build up a library of cases enabling comparability of judgement. For the majority of more or less typical schemes this is an advantage of a strong appraisal process.

Why isn't it a good idea to just let decision makers decide for themselves without any formal appraisal guidance? One reason is that human cognitive ability is limited – more limited than we like to think. This is exacerbated by our innate tendencies to identify with projects which are being promoted, and to be over-optimistic and over-confident in general and in our cognitive ability in particular (Kahneman, 2011). Even a benevolent despot who truly wishes to strive for the greatest common good of the people and make the best use of public money is liable to fail because of a number of psychological reasons that apply to humans in general:

- We are not good at considering many variables and aspects simultaneously; instead we tend to focus on one or very few aspects and are often unaware that we do this.
- We usually reach decisions very rapidly based on gut instinct or subconscious analogy. Then we tend to look for evidence and arguments which support the decision.
- We are prone to wishful thinking, optimism bias and loss aversion, so we have difficulties in abandoning an idea or a decision once we have settled for it.
- We tend to over-generalise, turning anecdotes or single cases into general rules.
- We are not good at understanding or comparing different orders of magnitude.

- Moreover, we are not aware of these processes and if made aware of them can find them quite threatening.

Decision makers may face hundreds of projects, either simultaneously or sequentially, and it is simply not possible to completely process all these options. In such situations, humans are bound to use simple heuristics, such as only focusing on one or a few aspects. Even worse, decision makers will most likely not be aware that they use a simplifying heuristics; they may honestly believe that they are taking all aspects into account.

Appraisal is potentially an antidote to this. It makes it easier to structure information and remember and consider all or most aspects of a suggested project. It enables orders of magnitude to be created that are comparable both across projects and types of effects. A framework within which impacts are quantified on a consistent basis forces decision makers to face up to numbers, so decreasing optimism bias and our inherent reluctance to give up beliefs and ideas.

Implicit in Figure 1 is a world in which there are many stakeholders – different levels of government, infrastructure providers, operators, transport users, representatives of environmental and planning interests. The case for a project is likely to look different from different perspectives. An analysis framework is a useful device for ensuring that relevant information is brought together in one place and in one way which is specified in advance in the rulebook. Activities such as Public Consultation and Public Inquiry are greatly facilitated by the existence of an appraisal framework. Moreover, it allows and supports decentralised decision making, including local public inquiries and local delegations of power.

Another reason for using CBA stems from the fact that it is not always politically rational to strive for the greatest common good. Policies where a small group of beneficiaries gain significantly at the expense of a large group which loses only a little are often politically rational. The larger group will often not care enough about a small loss to let it affect how they vote, while the large gain for the small group may be pivotal for which politician they will support (Harford (2009) provides an entertaining illustration of sugar production subsidies). Transport investments often have precisely this feature: any single investment takes a little from a large group (e.g. all taxpayers) while hugely benefitting a small group (e.g. a specific subset of travellers). Since any single investment is politically rational in this way, over-investment is the expected outcome. CBA acts as an antidote to this, especially if it is used to compare many investments against each other with a fixed budget constraint. In this sense, "CBA is the tax payers' only representative at the negotiation table" (a quote from Lars Hultkrantz).

While there is a well-established convention of using cost benefit analysis as a means of informing decision-makers about the impacts of transport schemes, the methods are also applied in other fields of public sector investment appraisal. For example, the UK Environment Agency makes use of CBA to determine the case for investment in flood protection and to prioritise between options. It is regularly used in the field of health economics, in the context of improvements to the quality of life enjoyed by patients and to options for environmental policy.

To summarise, CBA in transport can be seen as a way of civilising the process of handling conflicts inherent in deciding the level of funding at programme level, how scarce funding should be allocated within the programme and whether particular projects should proceed. So the CBA framework and the values within it are important not just in their own right but also because they confer legitimacy to contested decisions.

## 2.2 The Form of the Appraisal Process.

So far we have said nothing about particular appraisal techniques; the case for the analysis function has been put in generic terms. Now we ask – what form should the analysis take? This is not an easy question because a decision is in fact a package of decisions from the most strategic to the most detailed. Consider for example a proposal to improve transport quality in a dense urban corridor. It is convenient to think of three levels of questions

1. What goals are we trying to achieve and how do the various options score against those goals? Is the preferred option socially desirable, affordable and deliverable?
2. How do we enumerate and evaluate the size and distribution of the costs and benefits of the alternatives, and identify gainers and losers relative to the Do-Minimum or Reference Case?
3. Given the numerous choices of design, layout and technology, how do we optimise the cost-effectiveness of the scheme?

This setup is shown in Figure 2. At the upper level there is one synthesis of performance against strategic goals for and constraints on delivering the desired improvement. At the middle level there is an analysis of several scheme options of which one will be the winner. At the lower level in the hierarchy there will be hundreds or thousands of detailed choices to be considered. Exhaustive global optimisation is impossible; it is necessary to segment the analysis process in some way.

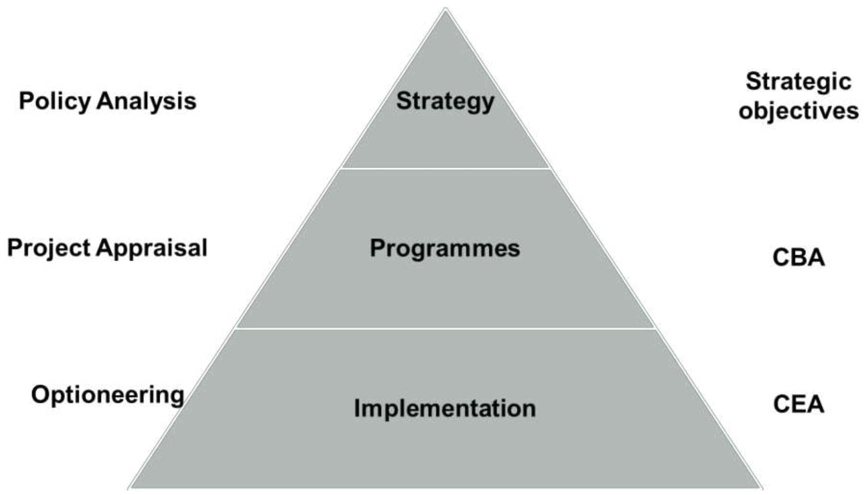


***Figure 2. The decision hierarchy.***

In some sectors, the middle level may be absent. For example, a national school building programme may contain a statement of objectives concerning meeting demand, class sizes, age of buildings, required facilities etc, and a design manual with specified classroom sizes, assembly room, labs and so on. Where the outputs are essentially homogeneous, this approach works.

In the case of transport though, there are multiple objectives and outputs. While the numerous designs for a scheme with specific set of outputs are usually compared on a cost-effectiveness analysis (CEA) or standards basis using a design manual, the final option selection and the ranking between schemes is facilitated if multiple outputs can be brought to, or at least towards, a single metric. Various multi-criteria methods are available for weighing up the balance of inputs and outputs from a scheme but in practice the favoured approach is cost-benefit analysis. Progressively over the last fifty years, this approach has been codified in official guidance manuals, sometimes running to hundreds of pages, for example WebTAG in the UK.

In its pure form, cost-benefit analysis (CBA) is a framework within which all impacts of a scheme can be brought together and compared using the money metric. Some features of CBA are listed below:

- It aims to be comprehensive in terms of the coverage of impacts
- It considers all relevant parties affected, adopting a society wide approach, and thus differs from commercial appraisal
- It seeks to obtain market or quasi market values for particular impacts and thus to base relative weights or values on willingness to pay. So relative to multi-criteria analysis it adopts user/citizen/market weights rather than planners'/politicians' weights.
- It is capable of being used to enumerate the distributional effects, who gains and who loses, at least with respect to first-order effects: how costs and benefits are dispersed in society as a whole in the long run is another issue, and it may be impossible to calculate this.
- It deals explicitly with the passage of time through the discount rate which is important for long life infrastructure projects and which other methods frequently struggle with.
- It is capable of delivering value for money metrics, and is a framework which permits treatment of risk and uncertainty and sensitivity testing.
- It is capable of being used at a decentralised level by agencies and their consultants and can be the framework within which appraisal information is presented for public consultation or public inquiry.

But there are various limitations of any technique of this kind and CBA is not magically exempt. First, there is a raft of *technical* issues. In particular, where do the values come from, how reliable are they and should they be private values or adjusted to social values? There is also the issue of how to handle impacts for which there are no values such as loss of natural or heritage assets. This is one reason why CBA typically needs to be viewed as a framework of monetised and non-monetised impacts which, however, leads to difficulties with the value for money metric. Secondly, there are *completeness* issues. The cost-benefit analysis does not tell us whether a scheme is popular or bitterly controversial nor whether it is fundable. Above all, CBA does not map on to all the higher order strategic objectives of the government.

The current UK Government has introduced the discipline of the Five Business Case Model within which projects are to be assessed in terms of their strategic, economic, commercial, financial and management (e.g. deliverability) cases. This is a form of Multi-Criteria Analysis but with no guidance on how to weight the performance in the different dimensions. The content of the CBA would be expected to drive the economic case and contribute to the strategic, commercial and financial cases. But the strategic case might go broader to address issues such as regional and social imbalances and macroeconomic performance.

This suggests that CBA continues to be a very useful tool of the trade within the analytical territory of Figure 1. It is particularly useful within programmes, for example for comparing schemes within a national highway programme where the scheme objectives and impacts tend to be broadly similar. When it comes to mega projects such as high speed rail, CBA can run into difficulties. This is partly because it is not easy to say what alternative form of expenditure the scheme is being compared with—quite possibly not in the transport sector at all. It is partly because mega projects are expected to have transformational and macroeconomic effects which are hard to handle using microeconomic tools. But also such projects tend to become politicised early, making cool dispassionate assessment of such projects problematic. In truth it is difficult for government to be both promoter and appraiser of such projects at the same time in the glare of the modern media.

Political visions have an unfortunate tendency to become too detailed too early. Early political commitment is the bane of cool judgement in decision making. Examples abound where worthy visions such as "promote a more balanced regional economy" or "increase liveability in urban cores" have quickly degenerated into engineering blueprints such as "build high-speed railways" or "build tram lines", even before costs or benefits of such schemes are remotely known. There is need for structured analyses of potential costs and benefits also at the most strategic level. One additional advantage of CBA is that it forces the options and their anticipated consequences to be clearly described. But decision-making on the strategic level is seldom developed or expressed in this way. Instead, it is phrased in terms of visions, targets and general directions. Weighing benefits against costs is still be a fruitful framework for analytic thought but the vision and analytical spheres depicted in Figure 1 can easily come into uncomfortable conflict.

## 2.3 Does CBA actually influence decisions?

Considering the limitations and constraints indicated above, one may wonder whether appraisal results actually influence decisions. A number of studies have investigated this question, many of them finding limited impact of appraisal results on investment decisions. There is a slight tendency, however, that the more recent studies to a larger extent find that objective costs and benefits actually matter for project selection.

Fridstrøm & Elvik (1997) and Odeck (1996) show no or very marginal impact of costs and benefits on project ranking in Norway. Nilsson (1991) found similar results for Sweden. Nellthorp and Mackie (2000) examined what road schemes were kept in the national Roads Programme by the incoming 1997 UK Government. The monetised benefit/cost ratio had no significant impact on decisions, but several specific factors had, such as noise, landscape, heritage, safety, journey time, reliability, regeneration and cost, so appraisal results taken as a whole seemed to influence project selection. Decision makers placed high implicit values on noise, landscape, heritage, reliability and regeneration, none of which were monetised in the CBA at the time, while downweighting travel time relative to its CBA value. Odeck (2010) found similar results in Norway: although benefit-cost ratios did not seem to affect investment decisions by the Norwegian Government, some of the components in a CBA seemed to matter. Eliasson et al. (2014) found no correlation between costs, benefits or any other variable and the investment decisions of the Norwegian Government or Road Administration, whereas there was at least some correlation for the Swedish Government's decisions, and a strong correlation for the decisions by the Swedish Transport Administration (confirming earlier results in Eliasson and Lundberg (2012)). Recent evidence from the UK indicate that appraisal results strongly affect project selection (UK Department for Transport, 2013). Schemes are categorised according to their BCR, adjusted to reflect decision makers' judgement on the extent of any unquantified impacts. This categorisation strongly affects selection: schemes in the two highest categories (adjusted BCR above 2) are generally approved, while a small number in the 'medium' category (adjusted BCRs between 1.5 and 2.0) might be approved if funding is available. The Department tracks, as one of its objectives, the proportion of expenditure spent on "high" or "very high" value for money schemes. For the past two years, almost 100% of spending was on schemes in the two highest categories.

The studies above all deal with the final stage of the investment selection process – selecting a number of projects from a relatively short list of candidates. But this may be a too limited view: appraisal may also affect earlier stages in the planning process. Our view is that by its very existence appraisal acts as a filter to prevent many weak schemes proceeding very far through the project cycle – at least if appraisal actually affects the eventual decisions, and decision makers and civil servants are aware of it. This is perhaps similar to other filters such as unacceptable intrusions on heritage or natural assets. So the negative function of appraisal, to act as a cultural discipline to help weed out the weak cases, is important. Eliasson et al. (2014) gives some evidence of this: in Norway, where there is no apparent correlation between appraisal results and project decisions, the candidate shortlist includes many more projects with very low BCRs than the corresponding list in Sweden, where there is a high correlation between appraisal and decisions. The "good ends" of the candidate lists, on the other hand, follow roughly the same BCR distribution. Eliasson and Lundberg (2012) interview Swedish civil servants, who confirm that since they know that appraisal will matter for the eventual decisions, they take this into account both when designing and shortlisting investments early in the process.

# 3 THE CONTENT OF TRANSPORT COST-BENEFIT ANALYSIS

Over the last two or three decades a position has been progressively built up where a number of countries are committed to using CBA as a framework and to conducting research and analysis to provide the value set within the framework. The results are then used in the Guidance Manuals which govern transport appraisal practice. A study done for the UK Government in 2013 summarises the position and compares CBA practice in seven countries: England, the Netherlands, Germany, Sweden, the United States, Australia and New Zealand (Mackie and Worsley 2013). The countries were selected partly for their data availability and are by no means the only countries with serious appraisal guidance. Also NGOs such as the World Bank, European Investment Bank and EU offer appraisal guidance; HEATCO (2006) provided a comprehensive review of the then current appraisal practice. Several of the seven countries also have highly standardised modelling and forecasting methods, ensuring that the travel costs and traffic volume inputs to the appraisal are comparable across schemes; for example, Sweden has a national transport model which is compulsory to use whenever applicable. A summary of some key results of the study can be found in the Appendix and here are some reflections.

## 3.1 General rules and parameters for Transport CBA

In most if not all countries, the Treasury or Ministry of Finance provides overarching guidance to which transport sector appraisal guidance needs to conform. The Green Book is the UK example (HM Treasury, 2013). Another is the recent Dutch General Guideline for Social Cost-Benefit Analysis (Romijn and Renes 2014). There is really no good reason for the discount rate to be chosen by the Transport Ministry and certainly not for it to be different from the rate used in the other sectors of the economy which are subject to public appraisal. Similarly, the approaches to the appraisal unit of account, the use or not of shadow prices on for example public capital, and the treatment of risk and uncertainty at least at the level of principle, should apply across sectors.

Our reading of Table 1 of the Appendix is that there is a high level of conformity of practice at this general framework level. Sometimes there are differences. For example the European countries go for what looks like a social time preference discount rate around 3 per cent while the US and Australasia go for an Opportunity Cost rate around 7-8%. Appraisal periods also differ, with countries using higher discount rates tending, unsurprisingly, to assume shorter project lives. Sweden uses a shadow price of public funds which raises the face value by 30%. The definition of the appraisal metrics, and particularly the benefit-cost ratio varies between countries. An interesting area is the treatment of transboundary effects and international traffic. While this is of little consequence for large countries, a significant practical issue is how to handle this in countries such as the Netherlands. Although the default nominal position is to count benefits and costs to the country—and this probably works well for sectors such as energy and water—for some transport projects it is not convenient or practical to segment the traffic by nationality and ways around the general guidance are frequently sought.

Overall though, the similarities far outweigh the differences. Countries use similar approaches for computing the present value of benefits and costs, they treat non-monetised impacts through some sort of framework tabulation, they have appraisal guidance manuals which advise and regulate scheme developers, and as a result many countries Ministries of Transport have delegated powers to approve transport projects which pass the tests without further recourse to the Ministry of Finance.

## 3.2 Benefit and Cost Values

The benefit values used in appraisal in the seven countries in spring 2013 are summarised in Table 2 in the Appendix. Three general points emerge from the detail.

Firstly, there is a good level of agreement within these seven countries about what can be valued in money terms, and a fair degree of similarity in the values used. Of course that might be explained by imitative behaviour, but there is a body of evidence, and there are outliers in the value set which would not be explained by copying.

Secondly, the evidence base for monetary values has widened. Compared with a decade ago, there is guidance on valuing changes in reliability and in overcrowding on public transport, and values for recurrent environmental impacts such as noise, local pollutants and greenhouse gases. A move has been made towards more complete monetary valuation of the direct impacts though in some cases such as reliability there are significant modelling and prediction problems. However, environmental capital such as effects on landscape, natural and heritage assets remain generally as qualitative descriptions in the framework.

Thirdly, the focus of the CBA itself has broadened out to try to encompass wider economy impacts. A number of countries seem to have come to a similar conclusion, that transport sector CBA was too narrow an approach and needed to be complemented in two ways. The first is to recognise the possibility of induced land-use change and the need for land-use transport interaction modelling for some types of project. Also, the additional wider economy impacts, notably agglomeration benefits from expanding capacity in cities are now incorporated in appraisal in several of these countries.

Taking these points together, the content of the monetised cost and benefit table has changed quite significantly. Arguably there has been more progress on this front in the last decade than in the previous four put together. No longer is there a rigid wall between time and safety benefits which can be measured in money and everything else which cannot. This is partly because transport investment is seen today much more as an agent of economic change than as an end in itself, and we return to this theme in section 4 below.

Comparing the valuations in more detail, and giving just a single reference to open the door to a wider literature, a few observations can be made:

- All countries differentiate the value of **travel time savings** by trip purpose. Most countries also differentiate by mode, except England and the Netherlands, but the Netherlands is apparently about to change this. Sweden also differentiates by trip length (longer or shorter than 100 km). Germany stands out by taking a different view of the "small time savings" issue, applying a 30% discount to road travel time savings below 5 minutes. All countries seem to use multipliers for waiting and walking, although the table reports only some of these. Hensher (2011) provides a useful review.
- **Safety** values and the relativities between fatal, serious and slight casualties are generally similar, although the USA has much higher values across the board and Sweden has much higher relative values for serious casualties. The US approach uses a hedonic model of wage compensation for risk applied to occupational mortality data, while the European methodology is based on stated willingness to pay to reduce risk plus a comparatively small addition for lost output. The value of statistical life has an importance beyond valuing traffic safety, being the basic value for deriving the health related benefits of increases in cycling and walking For a discussion, see Andersson and Treich (2011)
- Most countries use the standard deviation of travel time to measure road **travel time variability**, and then define the value of the standard deviation relative to the value of travel time (the so-called reliability ratio – "RR" in the table in the appendix). For scheduled traffic, most countries instead measure variability by the average delay relative to schedule, and then define the value of average delay relative to the value of travel time. Sweden also uses a lateness multiplier for long, unexpected delays in road traffic. All countries note the challenge of modelling the impact of projects.
- Most countries have multipliers to in-vehicle time for **crowding** relief on public transport. Some distinguish only between travelling seated or standing, while some use more elaborate crowding measures. Sweden and New Zealand also have mark-ups on in-vehicle time for driving in congested conditions.
- Several countries have introduced **fitness and health** benefits when appraising walking and cycling schemes. The practices in England and Sweden are based on the World Health Organisation's HEAT tool to estimate the relationship between physical activity and life expectancy. Australia and New Zealand have extensive guidance relating to walking and cycling. There is an unresolved discussion about the extent to which fitness and health effects affect travellers' behaviour, and hence are already internalised in travel demand and valuations, causing risk for double-counting.
- Most countries base their valuations of **carbon emissions** on a shadow price of some carbon emission target, and apply it to all transport energy use. Sweden has recently gone from a shadow price approach to basing the valuation on the $CO_2$ tax on motor fuel, and assume that this tax will increase proportionally to future GDP growth. England uses the forecast European Trading System prices for emissions

from the traded sector, and marginal abatement costs for the non-traded sector. The latter are currently substantially higher, with the two sectors assumed to align by 2030. The values used in England, Germany and Netherlands for the non-traded sector seem comparable for the early years, while Sweden's value is higher and the US' and New Zealand's much lower.

- Arguably the most disparate topic is how **wider economic impacts** (WEI) are treated. Work on WEI:s have been along two lines. The first identifies that the presence of tax wedges and agglomeration effects means that increases in accessibility will cause benefits external to the traveller, and hence not captured in the consumer surplus. The UK has been a forerunner in developing methods for quantifying these effects, and these methods are also used in Australia and New Zeeland. Sweden has developed a different method but based on a partly similar logic. See Mackie, Graham and Laird (2011) for a review. The second line of research focuses on inter-industry linkages, often with a special focus on freight transport, using regional input/output models or computable general equilibrium models. The USA is notable for considering a range of impact pathways beyond commuting, such as logistics and supply chain impacts, connectivity to corridors and gateways, and intermodal interchanges. Some of these approaches extend well beyond the economic welfare framework of cost-benefit analysis and are based on regional or local macroeconomic models.

## 3.3 Application of CBA across the transport sector

In all countries, the most important application of CBA is still appraisal of transport investments requiring public funds. In particular, it is used for projects where local levels ask for national funding. All the countries have transport appraisal manuals which are compulsory to use when evaluating projects with national funding. In cases where local or regional levels are responsible for funding, it is usually up to the local level to decide on evaluation frameworks. For example, some states in the US use CBA for state-funded projects, while others use multi-criteria analysis and still others have less formalized evaluation frameworks.

Carrying out CBAs is mandatory for road, rail and tram/bus investments in all the countries, at least if national funding is asked for. Walking and cycling projects are covered by most countries' guidelines, but such applications are rarer, probably because they seldom require national funding. Germany and the Netherlands also use CBA for appraising inland waterways projects. Few countries use CBA extensively for sea or air transport projects, although the UK has published as part of WebTAG the methodology it uses for government intervention in airport projects.

Maintenance of road and rail infrastructure is a large sector for which cost-effectiveness and life cycle models for asset renewal are more appropriate than full scale appraisal. The issue is usually not whether to close down an asset but how best to renew it and with what priority. Questions of upgrading and betterment may be more suitable for appraisal (what line speed, what capacity) and Australia makes reference to train refurbishment cases in this context.

Appraisal of changes to rail franchise specifications has been common in England, and recently appraisal guidance has been applied to national revenue support programmes for bus service provision. Sweden has made attempts at allocating scarce railway capacity among competing operators using CBA, but so far with limited success. There are also attempts at using CBA to evaluate pricing schemes; for example, it has been used in Sweden to evaluate the Stockholm congestion charging and a suggested national distance-based charge for trucks.

Finally, the role of appraisal in the public consultation and public inquiry processes should not be overlooked. Appraisal provides the framework, and much of the content around which planning issues such as route location, land take, mitigation and compensation are determined. The appraisal regime underpins a great deal of work on design choices and option development. This appears to be similar in most countries even if the precise arrangements differ.

# 4 APPRAISAL CHALLENGES

We have argued in section 3 that the practice of CBA for transport projects has made significant progress in recent years. Yet there is also a sense that the requirements on the analyst are becoming ever more demanding. Infrastructure projects have become more controversial over time, the appraisal needs to be both robust and exhaustive (the Environmental Impact Statement for the HS2 railway line in England is reputed to run to 55,000 pages), and legal challenges through Judicial Review have become more common. At the same time the consensus surrounding CBA as a suitable welfare economics paradigm has come under threat. Particularly since the global financial crisis, the question asked in several European countries is ' Why don't we just measure the effect of infrastructure on GDP and leave it at that'? Partly as a result of the loss of social consensus, planning timescales for new infrastructure have become extremely extended. Fifteen years from programme entry to open on the ground is not unusual of which the construction phase may be only the last two years. This is quite a contrast with the agility of global competitors.

Of course these issues go far beyond the question of appraisal which is a relatively small part of the process, but their existence is the backdrop against which to discuss the challenges which transport appraisal faces. We divide these into three types: technical, planning and policy.

## 4.1 Technical challenges

Some effects that are in principle included in a CBA are based on relatively unreliable methods and data. Below, we present our assessment of the most important areas for further methodological development. Our focus is mainly the conventional application area of appraising transport investments; methodological development for areas such as maintenance, pricing schemes and allocation of railway capacity introduce different requirements.

The outcome of a CBA is obviously fraught with many kinds of uncertainties. The future scenario assumptions underlying the forecasts are uncertain; the forecast effects of the project are uncertain; the final cost of the project is often uncertain; benefit valuations are both methodologically and philosophically contestable. There has been some recent progress in quantifying the uncertainties due to uncertain valuations, scenario assumptions, and cost and benefit estimates (Börjesson, Eliasson, & Lundberg, 2014; Börjesson, Jonsson, & Lundberg, 2013; Eliasson & Fosgerau, 2013; Holz-Rau & Scheiner, 2011). These studies generally conclude that the CBA ranking of alternative investments is in fact fairly robust to such uncertainties.

***Business travel time savings***

In a typical road or rail capital project, business travel time savings may account for 10% of traffic but 30% or more of user benefits. The valuation of these savings is hence hugely important for the outcome of a CBA. Despite this, comparatively little research has gone into this area. Most countries base their valuations on the "cost savings" approach, where the value of a travel time saving is equal to wage plus non-wage employment costs. But there are challenges to this assumption. The time use literature notes that people can work while travelling, so all travel time is not unproductive, and that parts of a travel time saving might be converted into leisure rather than work. These observations are formalised in the so-called Hensher approach (Hensher, 1977), which is used in some countries to at least some extent. These estimates generally give lower valuations than the cost savings method.

However, this approach is at odds with most empirical willingness-to-pay estimates, which usually yield considerably higher valuations. There may be several reasons for this, including difficulties of getting reliable data on travel costs, and the likelihood that business travellers' choose travel options that do not necessarily coincide with the firm's best interests. But there are also good explanations why the WTP for time savings should in fact exceed mere cost savings, starting from the observation that the benefit of spending time at the destination must exceed the benefit of spending time at the office, or otherwise the trip would not have been made (Karlström & Eliasson, 2007).

### *Commercial traffic*

Commercial traffic such as freight and distribution transport may make up 10-20% of traffic, and account for a higher proportion of the benefits. Despite this, data on this traffic is generally scarce, and the valuation of its time savings generally shaky. A particular problem is that travel time savings on a single link may have repercussions for entire logistics chains, making such savings difficult to model and value. Moreover, freight and distribution traffic is much more heterogeneous than person traffic is in terms of values of time, reliability and scheduling constraints.

### *Congestion and crowding*

It is well known that static network models cannot handle severe congestion well for a number of reasons, mainly because such models do not handle adequately the propagation of queues and the resulting congestion at the upstream intersections and junctions. An analysis by Engelson and van Amelsfort (2011) shows that this problem is not remedied by adjusting the volume-delay functions since the model still does not account for spillback queues. Hence, projects aiming at reducing road congestion may tend to be undervalued, and the costs of increased traffic congestion due to induced traffic may be underestimated. The long-term benefits of increased road capacity may be either over- or underestimated because of this.

Public transport crowding is a major problem in many large cities, and has received increasing policy attention. There has been significant recent progress on valuing crowding, but studies that model the consequences for reliability, travel times and potentially denied boarding are still relatively rare.

### *Supply/demand interaction problems*

Appraising publicly funded railway investments brings with it the particular problem that the benefits depend on how the investment will be used. For road investments, this is virtually exogenous from the point of view of the decision maker and the forecaster: the use is the sum of thousands or millions of individuals' decisions. But for public railway investments, the public usually has considerable influence on what trains will use the railway. In some countries, the government may be controlling the use; in others, the government establishes a regulator with responsibility for allocating capacity. In many cases, railways are used by a mixture of private operators (e.g. freight operators), publicly owned companies (e.g. national railway operators) and publicly funded and subsidized traffic (e.g. regional commuter trains). Hence, decisions about the future usage of the investment are integrated with the investment decision, and appraisal is impossible without explicit assumptions about this future usage. Despite this, few appraisal guidelines regulate this, leaving it to the analyst to decide what to assume about future usage and supply – frequencies, stopping patterns, allocation between different kinds of trains etc. This is somewhat similar to the appraisal of airport capacity decisions where predictions have to be made about how a regulated airport sector will behave and how private sector airlines will respond to changes in airport capacity and tariffs and to each other.

## 4.2 Planning

One of the main challenges for CBA is how it should be integrated in planning and decision processes. A CBA needs a fairly detailed description of the proposed project, and it is often the case that such detailed descriptions are available only late in a decision process. The trend towards "problem-oriented planning" may make this challenge even more severe. The idea of problem-oriented planning is to first identify "problems" in the transport system, and then look for solutions to those problems. Such processes often end up in identifying a certain investment as the only solution to the identified problem, concluding that even if the cost of the investment regrettably exceeds the benefits, it should be carried out anyway, since the problem is so severe. The catch lies in the definition of what exactly constitutes a problem. In some cases, this might be relatively uncontroversial: severe problems with air quality or road safety, for example. But more often, the identified "problems" rest on arbitrary definitions: for example, "inadequate" access to nearby labour markets, population centres, airports etc. Here, the definition of "inadequate" only serves as a motivation of a certain investment further on in the planning process. Such processes often accumulate enough backing from politicians and planners that the resulting investment proposals become very difficult to reject. As a result, projects may be selected on the grounds that a certain "problem" is perceived as severe, rather than on the grounds that the project actually is a cost-efficient solution.

Another problem for CBA is that the policy agenda has moved on from merely reducing travel times. The "3R"s – reliability, regeneration and resilience – are nowadays common goals for transport projects, and they are often difficult to quantify and hence to include in formal appraisal. Likewise, many projects have a local/regional economic development motive rather than a pure transport sector one. The common failure for CBA to find a role in planning processes may be a deeper difference in culture. Very generally, economists and engineers tend to think in comparative statics, while planners tend to think in dynamics. This may explains some of the mutual frustration often encountered in planning processes.

A third challenge for CBA is that it does not directly capture the fact that investments often belong in a particular planning context. Often, they are framed in a strategy to develop a city or a region in a specific way, for example, regarding the built environment. This planning context is not directly reflected in the CBA, although CBA can be used to evaluate different investments that all address the same "need" – say, to increase the accessibility of a specific part of a region to make it more attractive for development. This may partly explain the low impact of CBA on decisions: it may be that some highly profitable investments are not addressing needs that are prioritized in the overall strategic planning of a region.

## 4.3 Appraisal, Economic Impact and the Overall Business Case

A further challenge comes from those who believe that cost benefit analysis gives the decision maker the wrong answer. Several past government ministers have voiced scepticism about willingness to pay based benefits and their inability to cash the "fairy gold" in for a tangible effect on the real economy. The pursuit of an alternative metric to the BCR becomes more widespread when decision making is devolved to local or regional decision makers who are responsible for allocating part of a national budget to local schemes. The challenge takes the shape of deciding how to present evidence on how a scheme might perform against these other objectives using a range of methods, while ensuring some level of consistency between them.

### *A scheme's contribution to economic growth*

Despite evidence of the contribution of transport investment to economic growth at the macroeconomic level, analysts face a challenge when asked by a government minister to quantify the impact of a scheme on the economy. While such a question might seem out of place, given the relationship between the cost of any individual transport scheme and the overall GDP of a country, it is not an unreasonable one if posed by a transport minister seeking to justify a transport budget to a hard-pressed ministry of finance.

One of the strengths of social CBA is that it tries to capture all kinds of welfare effects – increases in leisure time as well as working hours, increases in accessibility to housing as well as accessibility to workplaces. But this is sometimes seen as a weakness; after all, the social benefits in a CBA are sometimes seen as lightweight fairy-gold. This criticism of CBA gets more weight by the fact that parts of the economic effects fall outside traditional CBA, for example at least some of the effects on productivity and tax revenues (although some countries have made efforts to bring these effects into standard CBA guidelines, notably the UK). The global financial crisis may have made politicians even more interested in real economic impact, and not the less tangible CBA social benefits. They want an account of how primary impacts flow through into the real economy.

This means that CBA now competes with evaluation frameworks which purport to measure the real economic effects, such as Gross Value Added methods. CBA and GVA can produce very different results for the same project, since there are several differences in scope and perspective. CBA tries to capture quality of life benefits, not just economic benefits, and tends to value benefits using population averages, for equity reasons, rather than the unprocessed willingness-to-pay measures (captured by prices) at the base of GVA methods.

A 2005 Discussion Paper 'Transport, Wider Economic Benefits and Impacts on GDP' published by the UK DfT provides an indicator of the GDP impact of a scheme. The indicator is the sum of the present values of what might be described as the real economy components of the cost benefit appraisal. It is made up of business and commercial vehicle time and operating costs savings, agglomeration benefits and the effect of any labour supply effects on gross value added (in place of the much smaller tax wedge that forms the labour supply benefit in the cost benefit appraisal). The resulting indicator, a present value of GDP per £'s worth of public expenditure, might form an alternative ranking to one which relies on a welfare based assessment of value for money. But the reputation of the minister of finance (or of Chancellor of the Exchequer in the case of the UK) hangs on delivering higher rates of economic growth than the pundits have forecast this year, next year and perhaps the year after. A metric based on the present value of GDP per £'s worth of public spending does not help a finance minister to know whether, by favouring transport over health or social security in the decisions about public spending, the government will outsmart the pundits and the minister's reputation will be saved.

### *Local and regional impacts*

Countries with federal governments generally devolve decision making on transport schemes to the state or regional level. In many cases the state or regional government has established its own appraisal guidance, which differs from the national in certain respects, such as the values put on some of the impacts of the scheme. The inconsistencies that arise from having certain differences in appraisal methods may complicate comparisons between options across the country, but this does not constitute a major challenge.

Cost benefit analysis takes a national perspective. Indeed, it is rarely feasible to provide any identification of the beneficiaries of a scheme beyond some crude approach based on the origins or destinations of the trips in the transport model. This presents a potential challenge for local politicians, who are elected to do their best for the locality and whose objectives differ from the national well-being that it is the duty of the central government to promote.

In many cases local politicians see their role as boosting employment and productivity in their area, a more tangible outcome of a transport scheme than transport user time savings. And it matters little to a local decision-maker whether the jobs attracted by a transport investment are additional jobs or are displaced from elsewhere within the country.

There are several approaches to estimating the impact of a transport scheme on the spatial distribution of economic activity in an urban area or larger region, including Spatial Computable General Equilibrium models, transport/land use interaction models complemented by data on economic activity, wage equation models and other models of urban agglomeration. All of these have their limitations. Much of the recent work has focused on agglomeration economies and hence provides no guidance on the impact of interurban schemes on productivity and employment. Yet there is a demand for models of transport's effects on employment and output to meet the requirements of local policy makers who want to know what a scheme will deliver for the local economy.

The challenge to CBA comes in the existence of dual objectives. The local politicians might decide to prioritise on the basis of gross value added in their region, irrespective of whether the jobs attracted are those that another region competing for funding had counted as part of its base case. Central government needs some assurance that the projects chosen by local politicians for their share of a nationally raised budget represent acceptable value for money.

### *Does a synthesis exist?*

The challenge that comes because of the dual objectives, a welfare-based one and a GVA based objective, is not insuperable. In the case of local transport schemes which are funded by central government, ministers might require all projects to meet some minimum cost benefit threshold, above which the ranking of options is for the local politicians to determine. The bigger challenge lies in the adequacy of the local transport/land use models or methods based on wage equations and agglomeration economies to predict to an acceptable level of accuracy the increase in productivity and jobs. And since the GVA models focus on the transport cost changes as the main measure of changes in the attractiveness of the city as a place to live and work and for employers to locate in, all of the other quality of life effects of a scheme now carefully incorporated in the cost benefit analysis are ignored.

The approach used in local schemes to estimate the employment and GVA effects is less satisfactory when applied at a national level because many of the benefits to one location are the jobs that are displaced from others. Recent developments in LUTI and urban agglomeration modelling have made progress in estimating the extent of this displacement of economic activity; however, this remains work in progress and is very different from the tried and tested methods of cost benefit appraisal. So a synthesis of the 'real economy' objective with the cost benefit appraisal becomes more problematic from the national perspective because of shortcomings in any model of the impacts of a project on national GVA.

# 5 CONCLUSIONS

Cost-benefit analysis has become a widely used and well developed tool for appraisal of proposed transport projects. An important advantage of using CBA is that it is a way to overcome cognitive, structural and process-related limitations and biases in decision making.

Our brief survey of a number of countries where CBA plays a formalised role in decision making shows a broad similarity in methods and valuations, based on substantial amounts of research. All countries place the CBA results in a comprehensive assessment framework that also includes various types of non-monetised benefits. Some parts of the appraisal methodology are undergoing rapid development; wider economic impacts and the valuation of reliability in particular come to mind. Still, there are areas sorely in need of methodological development, where less seems to have happened in the last decade. Considering their importance for appraising transport investments, time saving and reliability benefits for business travel and freight transport and the treatment of congestion and crowding relief stand out as particularly important to develop. Some of the biggest technical challenges are as much for modelling as for appraisal.

Some of the other main challenges to CBA and to quantitative assessment in general lie in the institutional and political context. Appraisal works best where society and its representatives have an open mind about the importance or social value for money of any project. Then, provided the analysis is timely, CBA has an important role to play in the decision process. When planning processes are centred around a politically predefined "problem" or "need", dispassionate analysis becomes much more difficult. This is particularly the case with mega-projects where the project may be funded out of a special budget and its opportunity cost in terms of projects foregone may be unclear. The solutions to such process issues lie in the institutional rather than analytical domain.

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# 8 APPENDIX: A CROSS-COUNTRY COMPARISON OF APPRAISAL PRACTICE

***Table 1. General Appraisal Framework Rules***

| | England | Germany | Netherlands | Sweden | USA | NSW Australia | New Zealand |
|---|---|---|---|---|---|---|---|
| Appraisal Period | Default 60 year operating life | Component specific service lives and annuity factors | Varies, e.g. 100 years or infinite | Varies 40-60 years depending on type of investment | Varies depending on project life cycle, typically 25 – 30 years | Varies – 30 years life for roads, 50 for rail tracks & tunnels, 35 for rail rolling stock, 15 for buses. Most rail evaluations 30 years. | Max 30 years for road projects, from the year in which significant benefit or cost commences. |
| Discount Rate | 3.5% for first 30 years then 3% | 3% | 2.5% (plus 3% risk premium) | 3.5% (changed from 4% recently) | Federal: 7% with sensitivity for 3%; States: vary 3-7% | 7 %, with sensitivity tests of 4% and 10%. | 8% (changed from 10% in 2008) |
| Unit of Account | Market Prices | Factor prices 1998 basis (updated to in review 2009/2010) | Was factor cost, but now market prices | Market prices | Market price | Factor cost | Factor costs |
| Shadow price of Public Funds | No shadow price | No shadow price | No shadow price | 1.3 | No shadow price | No shadow price | No shadow pricing. |
| Key appraisal metrics | NPV ; BCR | BCR; MCA scores for ERA and SIA | NPV ; BCR ; IRR | Net benefits/investment cost. | Primarily NPV, BCR; GDP and jobs sometimes | NPV, BCR, NPVI, FYRR | BCR(n), denominator is national econ costs. Also BCR(g), denominator is govt costs. FYRR to indicate optimum start date. |
| Treatment of non-monetised items in overall assessment | May adjust value-for-money category | Included, procedure to red-flag for special planning mandate | Presented in a standard format table | Presented in a standard format table. Considered in overall value-for-money rating | Qualitative assessment (most State DOTs use multi criteria analysis) | Can be included in a hybrid BCR calculation | Presented in a standard format table. |
| Risk and Uncertainty | QRA; Optimism Bias | Initially not included; sensitivity tests for demand and modal shift risks in review | 3% risk premium in discount factor | Not explicitly; maybe implicitly captured by discount factor, but does not vary between types of investments. | Uncertainty must be identified; risk analysis done where warranted | Contingency for risk added to base cost estimate- allowance for a specified level of risk in project implementation | Detailed risk analysis procedures described. No specific adjustment of costs or benefits for optimism bias, but guidance on cost contingencies at various stages in planning process. |
| Form of documentation | Green Book ; NATA ; WebTAG . | Report | OEI guidelines, SEE website | National guidelines in the "ASEK report", revised every ~3 years | Federal guidelines for each mode; states have own guidelines –on web & published docs | Guidelines –memo circular to transport agencies, publish on intranet | Economic Evaluation manual (EEM), maintained by NZ Transport Agency. |

*Table 2. Valuation of impacts (as of spring 2013; new values for time and reliability for Netherlands presented later in 2013)*

| | | England | Germany | Netherlands | Sweden | USA | NSW Australia | New Zealand |
|---|---|---|---|---|---|---|---|---|
| Travel Time Savings: | EB | £34.12/hr average of working persons | €19.97 /hr (1998), €23.50 /hr (2008) mode-/vehicle specific | 33-34 €/h | 247 SEK/h for trains, 291 SEK/h other modes | $23/h car, bus & train; $57 air & high speed rail | A$44/hr 2012 (128% of av weekly earnings/38 week-hrs) | Driver-car 32.67, LCV 32.13, MHCV 27.54. Pass-car, LCV, PT, cycle, pedn 29.73. |
| | Commuting | £6.46/hr | | 9-10 €/h | Trips shorter/longer than 100 km (SEK/h): Car 87/108; Bus 53/39; Train 69/73; Air 108 | $12 local commute, $17 intercity commute | Road A$13.76/hr, rail NSW $14/hr (40% of AWE/38week-hrs) | Driver-car, CV 10.69; Pass-car, CV 8.01; PT seated 6.44; PT standing, cycle, pedn 9.04. |
| | Other | £5.71/hr<br>Walk 2x IVT<br>Wait 2.5x IVT | 6.3 €/hr (2008); time savings below 5 min are reduced using a declining function | 6-7 €/h | Car 59/108; Bus 33/39; Train 53/73; Air 108 | $24 Walk & wait; Personal time: $12 for local vehicle travel, $23 for intercity travel, $32 for air & HSR travel | A$13.76/hr recommended by TfNSW. Rail uses $7-9/hr for educ/other trips but peak/off-peak values mostly used. TfNSW recommends Walk 1.15-1.5*IVT | Driver-car, CV 9.45; Pass-car, CV 7.12; PT seated 4.18; PT standing, cycle, pedn 5.82. [EEM1, A4.2] |
| | Goods and Bus Drivers | £13.00/hr | | | | $24 bus drivers, $25 truck drivers, $40 rail transit, $76 airline pilots | Freight/vehicle hr, i.e.<br>A$20.29 articulated 6 axle<br>A$29.37 B-Double<br>A$57.84 Triple road train | |
| Reliability (RR: stddev-value relative to IVT. Lateness multiplier (LM): value of average delay relative to IVT) | | RR 0.8-1.4;LM 3 | - | 25% surcharge on time benefits | Car: RR 9, LM 3.5. Train, PT: LM 3.5 | RR 0.8 – 1.1 based on the 80th – 50th percentile | RR 1.0. Rail LM 3.7 | RR approach is used. |
| Comfort and crowding multipliers relative to IVT | | Rail: 1.03-1.16 sitting in crowded conditions; standing 1.65 (short distance), 2.11 (long distance) | - | surcharges | Driving in congestion 1.5.<br>PT crowding: 1.0-3.0. | No | Crowding multipliers used for rail (relating to reduction in total IVT associated with the amenity improvement), pedestrian environment review system (PERS),<br>RailCorp has used a passenger rating approach to value station and train refurbishments. | Driving in congestion: VoT (not multiplier) up to 4.32 (driver), 3.22 (pass) for EB; up to 3.77 (driver), 2.81 (pass) other purposes.<br>PT crowding: 1.4 for standing |
| Safety | | Fatal £1.65m<br>Serious £0.186m<br>Slight £ 0.014m | accident costs differentiated by road types for accidents with material damages and | Fatal 2.744 M€<br>Serious 0.282 M€<br>Light 0.005-0.009 M€<br>Damage 0.004 M€ | Fatal 23.7 MSEK<br>Serious 4.4 MSEK<br>Slight 0.2 MSEK | Fatal $9.1 million<br>Serious $0.955m<br>Moderate $0.427m<br>Minor $0.027m | Fatal A$6.3m<br>Serious $466,614 | Fatal 3.798 $M<br>Serious injury 0.401 $M<br>Slight 0.021 $M. Costs per injury accident ($M)—50km/h speed |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| | | accidents with personal injury; | | | Damage $3285 per crash | | limit: fatal 4.020, serious 0.432, slight 0.025, PDO 0.002; 100km/hr fatal 4.560, serious 0.486, slight 0.029, PDO 0.003 |
| Wider economic impacts | Agglomeration Output change (Imp Comp) Labour mkt effect | Special bonuses for cross-border transport and connections with airports/seaports; | From RAEM or REMI model. Or: 1% more agglomeration gives 0.023% higher wages | Estimated relationship accessibility=>wage exists. Result quoted as "additional benefit" outside standard CBA. | Using TREDIS or REMI model; covers labour market and truck delivery mkt | Only included to date in large projects (adding around 10-20% to project benefits). E&Y Toll road analysis estimated lower national than NSW WEB benefits. | Agglomeration economies—apply only to large/complex urban tpt projects in major centres. Procedures use tpt model data and set of agglom elasticities to estimate changes in effective densities and hence productivity gains |
| Regeneration | Employment effects in RAs | Employment benefits regionally differentiated | Not included | No | Used in multi-criteria analysis | Population & employment gains on corridor from Transit Orientated Development included in larger PT schemes. | Not included. |
| Noise | Annoyance Value £10.91 per dB change per household per annum at 45dBA to £127 at 80dBA | WTP for annoyance €67.68 per noise resident equivalent at night (down to 37 dB(A)). Outside built-up areas (59 dB(A) sensitive sites, 64 dB(A) open space) | 29.97 per dB per person | Table of values for different dB values, in SEK/person. Different for train and road noise, and for indoors/outdoors exposure. | based on cost of sound barrier or land value impact, | Change in property values 0.9% per dB change in noise level. No effect below 50 dB(A) L10(18h). Rail projects have included per km figures. | Cost of road traffic noise = $410pa * dB change * # of h'holds affected [EEM1, A8.2] |
| Local Pollution | PM10, NOx. Marginal abatement costs where EU limits for NOx exceeded. | Global pollution €420/t NOxe. Local air quality: €1.24/yr per resident equivalent. Carcinogenic: 1.24 M€ per death. (2008) | PM10, SOx, NOx: combination of methods | Costs for PM2.5, VOC, SO2, NOx.SEK/exposed person. Varies with "ventilation zone" (topography etc.). | PM10, NOx, SOx. VOC, | 0.001 * change in $PM_{10}$ concentration * population exposed * normal death rate * value of life | 0.001 * change in PM10 concentration * exposed population * normal death rate * value of life. |
| Climate Change | Non traded £/tonne CO2e 2010 £ 53.58 2050 £207.28 | €205 /t CO2 (1998) €70 /t CO2 (central), €20 low, €280 high (2008) for review | 62.66 per tonne CO2 | 1 SEK/kg short run (short term policy, timetables etc.) 1.5 SEK/kg long run (investments) | $19 - $21 per ton CO2 | Australia has introduced a carbon tax which has raised electricity charges and also reduced rail fuel duty rebate (increased rates by around 1%). Road freight exempt to mid-2014. | CO2 $40/tonne CO2 , or 4% of VoC changes. |
| Environmental Capital (Landscape, Biodiversity, Heritage) | Qualitative assessment | Qualitative and MCA scores from ERA and HDA | Qualitative | Qualitative assessment | Qualitative assessment, represented in multi criteria analysis | | Largely descriptive/qualitative |
| Other | | Qualitative and MCA | | | -- | Water Pollution | Category of 'national strategic |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| significant--<br>please specify | | score from spatial impact assessment;<br>Recognition of project interdependencies;<br>Mark-up for induced traffic | Noxious fumes | | | Urban separation<br>Upstream & Downstream costs | factors'—includes Security of access (in the light of potential earthquakes, land slips etc) and Investment option values (flexibility to future uncertain demands etc) |

NOTE At the time of reporting, £1 = 1.15 EUR = 9.75 SEK = 1.50 USD= 1.45 AUD= 1.80 NZD

***Table 3. Research sources and dates***

| | | **England** | **Germany** | **Netherlands** | **Sweden** | **USA** | **NSW Australia** | **New Zealand** |
|---|---|---|---|---|---|---|---|---|
| Travel Time Savings: | Employers Business | WebTAG 3.5.6 | On-going projects for time costs in passenger and freight transport for BVWP 2015. | HCG (1998) | Eliasson & Karlström (2010) | 2011 USDOT Revised Guidance on Valuation of Travel Time | TfNSW Principles and Guidelines for Economic Appraisal of Transport Investment & Initiatives | Beca Carter Hollings & Ferner Ltd, Steer Davies Gleave, Forsyte Research, Brown Copeland & Co., (2002), Review of Benefit Parameter Values for Economic Evaluation |
| | Commutin g | 1994 AHCG National Value of Time Study plus | | HCG (1998) | Börjesson & Eliasson (2012) | Same as above | Values based on 1997 Austroads harmonised travel time valuation review study.<br>For rail, estimates based on Douglas Economics 2010/11 Survey | Beca Carter Hollings & Ferner Ltd, Steer Davies Gleave, Forsyte Research, Brown Copeland & Co., (2002), Review of Benefit Parameter Values for Economic Evaluation |
| | Other | 2003 ITS Value of travel Time Savings in UK | | HCG (1998) | Börjesson & Eliasson (2012) | Same as above | Douglas Economics/ RailCorp Survey 2010/11 | Beca Carter Hollings & Ferner Ltd, Steer Davies Gleave, Forsyte Research, Brown Copeland & Co., (2002), Review of Benefit Parameter Values for Economic Evaluation |
| Reliability Effects | | WebTAG 3.5.7<br>Range of sources for Netherlands MOT 'Value of reliability in Transport (2005) | n.a.; Recent research project by significance et al. (2012) for BVWP 2015. | Besseling et al. (2004) | Stddev: Eliasson (2004), Train delays: Börjesson & Eliasson (2011) | 2012 Report, SHRP L03 | TfnSW Principles and Guidelines<br>DEL/RailCorp<br>ATC Guidelines | Congestion and reliability, roads: Beca Carter Hollings Ferner Ltd and Sinclair Knight Merz (2002).<br>PT reliability: M Vincent (2008). LTNZ Research Report 339 |
| Comfort/ Crowding | | PDFH informed by MVA (2010) and Wardman (2012). | - | CPB and KIM (2009) | Crowding: Wardman 2012, Congested driving: Wardman 2012 and Eliasson 2004 | none | Rail train and station crowding SP studies and rating survey by Douglas Economics/RailCorp 2004-06, TfNSW train load surveys. | Beca Carter Hollings & Ferner Ltd, Steer Davies Gleave, Forsyte Research, Brown Copeland & Co., (2002), Review of Benefit Parameter Values for Economic Evaluation |
| Safety | | WebTAG 3.4.1<br>Based on Hopkin and Simpson TRL RR163, 1995 updated for parameters+value | BAST (2000); | SWOV (2009) | Hultkrantz & Svensson 2007 | 2013 USDOT Guidance on Treatment of the Economic Value of a Statistical Life | TfNSW Principles & Guidelines, Willingness to Pay Study (Hensher & PWC) | See EEM1 A6.11. Also for unit crash costs (MoT 2012):http://www.transport.govt.nz/ourwork/Land/landsafety/Pages/TheSocialCostofRoadCrashesandInjuries.aspx |
| Wider economic impacts | | WebTAG 3.5.14<br>Based on DfT (2005) informed by Graham et al (2005/6/9) | | Groot et al. (2010) | Anderstig et al., unpublished.<br>Variant published in Anderstig et al. | Description of US practice in NCHRP 02-24 Lit Review (2013); methods in REMI and TREDIS | WEB model developed by TfNSW, Hensher et al (2012) referenced in TfNSW Manual | Graham DJ and Mare DC (2009) Agglomeration elasticities in New Zealand. NZ Transport Agency research report 376 |

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| | | | | 2012 | documentation | | |
| Regeneration | WebTAG 3.5.8<br>Based on DfT (2003) Guidance on Preparing an Ec. Impact Report | | - | | | Variable.<br>Benefits included for rail projects forecast to regenerate brown field sites e.g. Airport Rail Link. Denis Johnson & Associates, 1994. | |
| Noise | WebTAG 3.3.2<br>Values based on Bateman et al (2004) with benefit transfer by Nellthorp et al. | Weinberger et al. (1991) for WTP for residential noise<br>Jansen (2000) for outdoor noise | INFRAS/IWW (2000) | Train: Swärdh 2012 | 2011 USDOT Noise Analysis and Abatement Guidance | RTA & Austroads Economic Analysis Manuals | See EEM1 A8.2, A8.11 |
| Local Pollution | WebTAG 3.3.3<br>Based on ICGB (AQ) DEFRA 2008 | UBA (2007) | CE Delft (2001) | Derived from ARTEMIS | 2012 TIGER Grant Guide; 2010 NHTSA Regulatory Impact | RTA & Austroads Economic Analysis Manuals | See EEM1 A9.8 |
| Climate Change | WebTAG3.3.5<br>Shadow price of carbon based on Stern (2006) and updated in line with DECC 2011 | UBA (2007) | CE Delft (2001) | Derived from CO2 on fuel | US Govt. Inter-Agency Working Group (2010); also US EPA, 2010 | RTA & AustRoads Economic Analysis Manuals | See EEM1 A9.6 |
| Environmental Capital ( Landscape, Biodiversity, Heritage) | WebTAG 3.3.6-9<br>Approach unchanged since 2006 but recent study by Atkins/ Metroeconomica | PÖU (200) | Ruijgrok et al. (2007) | | -- | RTA & AustRoads Economic Analysis Manuals | See EEM1 A8.11 etc |
| Other significant--please specify | | Induced traffic: STASA et al. (2000)<br>SIA (Würdemann & Sieber, 2004) | Bogaert et al. (2005) | | -- | RTA & AustRoads Economic Analysis Manuals | |

*Table 4. Applicability of appraisal*

| | | England | Germany | Netherlands | Sweden | USA | NSW Australia | New Zealand |
|---|---|---|---|---|---|---|---|---|
| Capital projects--- large/small | Road | Mandatory | Mandatory | Mandatory | Mandatory | USDOT Grants: Mandatory CBA StateDOTs: varies | Mandatory | Mandatory for all projects applying for central government transport funding allocation from the National Land Transport Fund. |
| | Rail | Mandatory ; WebTAG values supplemented by rail specific values from PDFH | Mandatory (BVWP for federal, Standardisierte Bewertung for state / regional) | Mandatory | Mandatory | USDOT Grants: Mandatory CBA StateDOTs: varies | Rail Passenger mandatory. Rail freight depends on locality. ARTC mainly responsible for rail freight infrastructure appraisals outside metropolitan Sydney. Within metropolitan area, evaluations have been undertaken by agencies of NSW government eg Northern Sydney Freight Corridor. | Complicated. 'Above rail' urban pax projects –mandatory for NLTF funding. 'Below rail' projects—'catch-up' investment programme been funded direct from central govt funds over last 10 years; current segregated funding for passenger transport (NLTF service only subsidies) and freight (now fully commercial and no subsidisation) with below rail track access charge according to use. |
| | Bus/Tram | Mandatory | Mandatory for large investments | Mandatory | Sometimes; mandatory if national funding is applied for | USDOT Grants: Mandatory CBA StateDOTs: varies | Mandatory | Mandatory for infrastructure seeking NLTF funding contribution. (Most vehicles funded by operator through operating contracts.) |
| | Air | WebTAG Unit 3.18 provided guidance for government intervention including policies, strategy, regulation, planning applications | State responsibility; general budgetary and planning law; no specific appraisal guidance | Mandatory | Seldom | USDOT Grants: Mandatory CBA StateDOTs: varies | Largely Commonwealth responsibility. larger airport evaluations usually submitted to NSW Treasury. | Completely separate from funding of land transport. Airport authorities and airlines operate on a commercial basis and have own evaluation/funding procedures. |
| | Sea/Water | Port capacity through planning system. Mode shift from road appraised (ref to Waterborne Freight Grant) | Mandatory for Inland Waterways as part of BVWP; Seaports are state responsibility and fall under general budgetary and planning law with no specific appraisal guidance. | Mandatory | Sometimes | USDOT Grants: Mandatory CBA StateDOTs: varies | Passenger (urban) Ferry covered under TfNSW Economic Evaluation Manual. Port expansion via Environmental Impact Statement including Economic Impact Assessment and road/rail traffic analysis. | Completely separate from funding of land transport. Ports and shipping lines operate on a cxommercial basis, with own procedures. |

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|---|---|---|---|---|---|---|---|---|
| National | | Mandatory for national vfm | Mandatory (BVWP) | Mandatory | Mandatory | USDOT Grants: is Mandatory CBA | Mandatory for NSW transport projects seeking national funding (Infrastructure Australia). | Mandatory evaluation procedures (EEM) for all national roads |
| State | | n/a | Mandatory for large public transport investments (Standardisierte Bewertung); non-binding guidance for road investments (EWS) | n/a | n/a | StateDOTs: CBA or MCA (varies), usually also EIA | Mandatory for strategic alignment and VFM | n/a |
| Local | | Local/Regional GVA approaches increasingly for Local Econ Impact | Guidance (Standardisierte Bewertung and EWS) | Discretionary | Seldom | Metropolitan Planning Orgs: MCA or EIA | Discretionary | Mandatory evaluation procedures (EEM) for all local rods projects seeking central government funding. |
| e Expend | Maintenance | Unlikely except betterment | Investments for renewal of federal roads included in BVWP; | ? | Attempts are made | Use lifecycle cost models for pavement & bridges | Major train refurbishment s subject to appraisal, programs above business as usual. | Roads: other than routine mtce, road/bridge renewals etc are subject to EEM procedures [EEM1, 4.2 etc] |
| | Subsidies | Variable; increasing use. Yes for assessing rail franchise bids and for mode shift revenue support | According to budgetary law (§7) all public expenditures have to undergo an appropriate economic assessment, but no specific procedures are prescribed. | ? | Seldom; certain pricing measures (e.g. kilometre charges) | Yes, CBA and FIA for PPP, toll projects | Increasing use for bus fleet evaluations and assessment of franchise bids.<br>PT fares & subsidy levels assessed by Independent Pricing & Regulatory Tribunal of NSW. | Changes in PT operating subsidies associated with service changes/new servicer are subject to EEM procedures. On-going op subsidies for current PT services not subject to EEM, but scrutinised using various VfM indicators. |
| Appraisal relevant for: | Public Consultation | Yes | Yes | Yes | Yes | Varies among states | As required | To a limited extent. |
| | Planning Inquiries/ Permission | Yes—significant quality control role in PI setting | Yes | Yes | Yes | Varies among states | Yes, CBA for road and rail projects often included. Economic Impact Assessment plus traffic assessment for ports and airports). | To a limited extent. |

US terms: CBA= cost-benefit analysis, MCA=multi-criteria analysis ranking; EIA=economic impact analysis, FIA=fiscal impact analysis