Developing a consistent cost-benefit framework for multi-modal transport appraisal

A report for the Department of the Environment,
Transport and the Regions

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Summary

A number of different methodologies are currently used in the UK to appraise transport projects which are wholly or partly financed by central government. This report investigates the extent of consistency between existing methodologies. It makes some broad proposals about the design of a common methodology of cost-benefit analysis (CBA), which can then be located in a wider framework of appraisal of the kind currently favoured by the Government.

The following areas in which existing methodologies do not agree are examined:

- *The 'calculus of social costs and benefits' versus the 'willingness-to-pay calculus'*. The willingness-to-pay calculus (in which the effects of a project are identified separately for different groups, defined by their economic role) is recommended on the grounds that it facilitates disaggregations of costs and benefits -- particularly between financial and non-financial impacts of projects -- which provide important information to decision-makers.

- *The unit of account: values at factor cost or at market prices.* The report explains the difference between these two units of account, and proposes the market price unit as a convention.

- *The treatment of project impacts on indirect tax revenue.* It is recommended that these impacts are included in CBA, but separated out from other project impacts in the final presentation of costs and benefits.

- *The treatment of user benefits of public transport services*. The arguments for and against including user benefits are considered. Since these arguments raise fundamental issues of principle which have yet to be resolved, the report recommends a 'spreadsheet' presentation of the results of CBA, in which user and non-user benefits are separated out and in which the trade-offs that have to be made are transparent.

- *'Equity' versus 'behavioural' values of time*. It is argued that the 'equity' value of time, as currently used in highway appraisals, is incompatible with the logic of CBA. The use of 'behavioural' values is recommended.

- *Treating accident risks as 'perceived' or 'unperceived' costs of travel.* In highway appraisals, accident risks are treated as unperceived costs. This treatment appears anomalous, and further consideration of the issue is recommended.

Using the COBA procedure for highway appraisals as a template, but adapting this in the light of the various issues of consistency mentioned above, the report outlines a cost-benefit methodology which

can be used for the appraisal of multi-modal transport projects. Finally, the report makes suggestions about how this methodology might be incorporated into the 'new approach to appraisal'.

1 Introduction

1.1 A number of different methodologies are currently used in the UK to appraise transport projects which are wholly or partly financed by central government. In the light of the government's commitment to an integrated approach to transport, it is important that the methodologies used for different types of transport appraisal should be mutually consistent; ideally, a single appraisal methodology, applicable to all transport projects, should be used. This report investigates the extent of consistency between existing methodologies. It makes some broad proposals about the design of a common methodology of cost-benefit analysis, which can then be located in a wider framework of appraisal of the kind currently favoured by the Government.

1.2 Since the 1970s, trunk road schemes have been appraised using a computerized cost-benefit analysis program, COBA, designed by DETR (or by using a variant of that program, URECA [Urban Economic Appraisal]). This methodology is described in the *COBA Manual* (Department of Transport, September 1996).

1.3 Applications for central government grants for capital expenditure on public transport under Section 56 of the Transport Act 1968 are appraised differently. The 'Section 56 methodology', set out in Department of Transport Circular 3/89 (November 1989) and its supplementary note Annex A (April 1991) is not a comprehensive cost-benefit analysis (CBA). It is a 'restricted CBA' based on the criterion that the benefits of a scheme *to non-users* should be greater than the grant contribution. From 1993, it has been required that applications for Section 56 grants should be accompanied by comprehensive CBA appraisals, but the methodology to be used in these appraisals and the role of these appraisals in the decision-making process has not been spelled out.

1.4 The then Department of Transport, in partnership with a group of local authorities, commissioned a study which in 1994 proposed a comprehensive CBA methodology for urban transport projects (*Common Appraisal Framework for Urban Public Transport Projects*, a report by the MVA Consultancy, Oscar Faber, and the Institute for Transport Studies, University of Leeds, February 1994 [henceforth *Common Appraisal Framework*]). This methodology was intended as a guide to best practice for the CBA appraisals required for Section 56 applications and local transport packages.

1.5 The Office of Passenger Rail Franchising (OPRAF) has proposed a comprehensive CBA methodology for the appraisal of proposals from train operating companies for changes in Passenger Service Requirements (e.g. changes in the frequency or speed of services) and associated changes in the required level of OPRAF financial support. This methodology was described in outline form in a paper of 1996 (*Appraisal of Support for Passenger Rail Services: A Consultation Paper*, OPRAF,

November 1996 [henceforth *OPRAF Consultation Paper*]). After a consultation exercise, OPRAF proposed an amended methodology in the paper *Appraisal of Support for Passenger Rail Services: Planning Criteria -- an Interim Guide* (OPRAF, November 1997 [henceforth *OPRAF Interim Guide*]).

1.6 In July 1998, DETR set out a 'new approach to appraisal', which is presented as part of a conception of integrated transport (*A New Deal for Trunk Roads in England: Understanding the New Approach to Appraisal*, DETR, July 1998 [henceforth *Understanding the New Approach*] and *A New Deal for Trunk Roads in England: Guidance on the New Approach to Appraisal*, DETR, July 1998 [henceforth *Guidance on the New Approach*]). The 'new approach' is a wide-ranging appraisal methodology, based on five principal criteria: 'Environmental Impact', 'Safety', 'Economy', 'Accessibility', and 'Integration'. In its current form, it is applicable only to trunk road appraisals. It uses valuations taken from the COBA program as 'quantitative measures' of various 'safety' and 'economy' impacts of projects, but the underlying appraisal framework is not CBA. The aim of the new approach is to display information about the impacts of a project on various dimensions which are relevant to the appraisal criteria. This information is presented in a consistent and compact form, but no attempt is made to reach a definite recommendation by applying weights to the different criteria.

1.7 Section 2 of this report considers, at a general level, the place of CBA in the 'new approach to appraisal'. Sections 3 to 8 deal with inconsistencies between the CBA methodologies referred to in paragraphs 1.2 to 1.4, and make proposals about how those differences should be reconciled. Some of these inconsistencies were the subject of a previous report (*The Treatment of Taxation in the Cost-benefit Appraisal of Transport Investment*, Robert Sugden, Economics Research Centre, University of East Anglia, April 1998 [henceforth *Treatment of Taxation*]); some paragraphs from that report are repeated in the current report. Sections 9 and 10 present the broad outlines of a common cost-benefit appraisal methodology for transport projects. In developing this methodology, COBA is used as a template. Thus, Section 9 describes the COBA methodology for trunk road appraisal and then revises this in line with the principles of reconciliation recommended in the preceding Sections. A simple spreadsheet presentation of a trunk road appraisal, using this revised methodology, is described. Section 10 extends this spreadsheet approach so that it can be used for other forms of transport appraisal. Section 11 looks at how benefits can be disaggregated so as to provide information relevant to individual decision-making criteria. Drawing on that analysis of disaggregation, Section 12 makes some suggestions about how a multi-model CBA methodology might be integrated into the 'new approach'.

2 Cost-benefit analysis in the 'New Approach to Appraisal'

2.1 The recent DETR papers *Understanding the New Approach* and *Guidance on the New Approach* present the outlines of a transport appraisal methodology, applied to trunk road projects. This is based on five principal criteria, 'Environmental Impact', 'Safety', 'Economy', 'Accessibility', and 'Integration', some of which are broken down into sub-criteria (*Guidance on the New Approach*, Chapter 5). CBA appears in this framework in two different ways:

- Valuations of specific costs and benefits taken from the standard COBA (or URECA) cost-benefit program are presented as separate items under the 'Safety' heading and under various sub-criteria of 'Economy'.
- 'Cost-benefit analysis' appears as a final item in the 'Appraisal Summary Table', distinct from the five criteria. Four summary statistics from COBA (present value of benefits, present value of costs, net present value and benefit-cost ratio) are shown. These statistics are included 'in order to provide a means of comparing, over time, the previous approach to appraisal with the new approach to appraisal' (*Understanding the New Approach*, par.10.2).

2.2 The intended place of CBA in the new methodology is unclear. Read literally, the implication of paragraph 10.2 of *Understanding the New Approach* is that the information presented under the 'Cost-benefit analysis' heading is not intended to be used in decision-making; it is merely there for monitoring purposes and is expected to become redundant as the new appraisal methodology becomes established.

2.3 However, it is also possible to interpret the new approach to appraisal as a whole as providing the basic structure for a more ambitious form of CBA than COBA. On this view, the various criteria and sub-criteria refer to items which, ideally, would correspond with costs and benefits in a comprehensive CBA. Where possible, the 'quantitative measures' are monetary values of costs or benefits, appropriate for inclusion in a CBA. Non-monetary measures are used in those cases in which current CBA methodology is thought inadequate or unreliable, but the possibility remains open that improvements in methodology will eventually allow some non-monetary measures to be replaced by monetary ones. In other words, comprehensive CBA remains as an aspiration.

2.4 This report is premised on the latter interpretation of the new approach to appraisal. Given this starting point, it is important that the criteria and sub-criteria used to structure the appraisal framework match up with items that can meaningfully be separated out in a CBA. Most importantly, those quantitative measures that already derive from CBA should be presented in a way that is compatible with cost-benefit accounting. Thus, for these items, units of measurement should be consistent and there should be no omissions or double-counting. For items which are not measured as

monetary costs and benefits, it should be clear whether these are *additional* costs or benefits which have escaped measurement in the cost-benefit accounts, or whether they are *redescriptions* of, or *incidences* of, costs and benefits which have been included elsewhere. For example, many of the transport-induced benefits of urban regeneration are included in the conventional cost-benefit measurements of the benefits of time savings and of traffic generation. In forming an overall judgement about a transport project, it may be relevant to consider its effects on regeneration, and so information specifically about these effects can be useful. But it is still necessary to know whether these effects are additional to other benefits, or merely part of them.

2.5 Sections 3 to 10 address the problem of developing a consistent CBA methodology for transport appraisals, with broadly the same scope as the existing methodologies mentioned in paragraphs 1.2 to 1.5. Sections 11 and 12 consider how such a methodology might be fitted into the new approach to appraisal.

3. Consistency between methodologies: calculus of willingness-to-pay or calculus of social costs and benefits?

3.1 This Section, and the succeeding Sections 4 – 8, investigate a range of issues in transport appraisal, in relation to which current methodologies are not wholly consistent.

3.2 A CBA aims to take account of all the ways in which a project affects people, irrespective of whether those effects are registered in conventional financial accounts. It can be described in two different ways - as a *calculus of willingness-to-pay* or as a *calculus of social costs and benefits*. These lead to two different ways of presenting the cost-benefit accounts, but (if properly carried out) both lead to the same valuation of net social benefit.

3.3 The basic strategy of the willingness-to-pay (WTP) calculus is to arrive at a money measure of the net welfare change for each individual that is brought about by the project under consideration, and then to sum these. The welfare change for any individual is measured by the *compensating variation*, i.e. the individual's WTP for benefits or the negative of his/her willingness to accept compensation for disbenefits. The principle behind this calculus is the Kaldor-Hicks *compensation test*: a move from one state of affairs to another passes this test if, in principle, those who benefit from the move could fully compensate those who lose (without themselves becoming losers). When the cost-benefit accounts are presented in this way, there often are items which appear as benefits for one person and equally-valued costs for someone else: such items are *transfer payments* or *pecuniary externalities*. Items which do not cancel out in this way are *social* costs or benefits (sometimes called *resource* or *real resource* costs or benefits). The word 'social' is used to signify that these are costs or

benefits which fall on 'society as a whole', understood as the aggregate of all individuals.

3.4 The calculus of social costs and benefits seeks to measure the value of the 'resources' used by, and the benefits created by, a project. This approach distinguishes between social costs/benefits and transfer payments at the outset, and takes account only of the former. For example, consider a straightforward market transaction: a person buys and consumes a can of beer. In the calculus of social costs and benefits, the marginal cost of producing the beer is a social cost, while the consumer's enjoyment of the beer is a social benefit; the actual payment made for the beer is a transfer payment, and is ignored. (In contrast, the calculus of WTP would record a benefit to the consumer equal to the consumer's surplus on the beer, i.e. the excess of WTP over the price paid, and it would record a benefit to the producer of the beer equal to the producer's surplus, i.e. the excess of price received over marginal cost.) Because the calculus of social costs and benefits nets out transfer payments, this approach does not allow the net social benefit of a project to be disaggregated into impacts on different economic interest groups.

3.5 Clearly, the two methods are equivalent. It is important to realise that the difference between the two methods is simply a difference in presentation. It is *not* a difference between wider and narrower ways of defining the class of effects that ultimately count in CBA.

3.6 When CBA was first widely used in the 1960s, it was conventional to use the calculus of social costs and benefits. It is perhaps a sign of the long history of the use of CBA in DETR and its predecessor departments that the COBA methodology uses this approach. More recently, however, there has been a tendency for cost-benefit analysts to prefer the calculus of WTP. For example, this is the method used by Alan Williams and me in our book *The Principles of Practical Cost-Benefit Analysis* (Oxford University Press, 1978 [henceforth *Principles of CBA*]). The OPRAF methodology uses the calculus of WTP. So does the *Common Appraisal Framework* report.

3.7 The principal advantage of the calculus of WTP is that it leads naturally to a presentation of results which makes clear how a project impacts on the members of different economic interest groups (e.g. car users, public transport users, taxpayers), rather than hiding distributional impacts in the aggregation of resource costs and benefits. Similarly, financial and non-financial impacts can be readily distinguished from one another. The latter kind of disaggregation is particularly important when projects are sponsored or co-sponsored by private sector firms, or by public sector agencies which are expected to act in a quasi-commercial way (i.e. to have regard to their own financial balance sheets). For a traditional highway project, where all costs are borne by a government agency and the services of the road are provided to users free of charge, the distinction between financial costs and non-financial benefits is straightforward; in such an application, the calculus of social costs and benefits may be acceptable. But almost all public transport, and some roads, are now supplied by

private firms. A common CBA methodology for the transport sector needs to lead to the kind of balance sheet that is generated by the calculus of WTP. For this reason, the appraisal framework proposed in this report uses the calculus of WTP.

4 Consistency between methodologies: the unit of account

4.1 Any CBA needs a numéraire, or unit of account. Obviously, the most convenient unit of account is money. But in an economy with indirect taxes, the unit of account can be *at factor cost* (i.e. net of indirect tax) or *at market prices* (i.e. gross of indirect tax). If we focus on the resources used to produce output, it is more natural to use a factor-cost unit, since most indirect taxes are levied only at the final consumption stage. But if we focus on people's willingness to pay for final consumption, a market-price unit of account may seem more natural, since prices to consumers are generally quoted gross of tax.

4.2 Which unit is used in CBA is of no real significance (just as it is of no significance whether amounts of money are expressed in pounds or pence); but consistency is essential. The *indirect tax correction factor* is the conversion rate between the two units. If CBA uses the factor-cost unit, a correction factor has to be applied to any costs or benefits that have been measured gross of tax. Conversely, if the market-price unit of account is used, the reciprocal of that correction factor has to be applied to costs or benefits that have been measured net of tax.

4.3 The basic idea behind the indirect tax correction factor can be stated very simply. (This argument can be found in Department of Transport Highway Economics Note No. 3 [written by M.A. Schraer and dated December 1977] and in *Principles of CBA*, pp. 109-110. A fuller discussion is given in *Treatment of Taxation*).

4.4 Denote the average rate of indirect tax on final consumption by t. Thus, goods which are valued at £1 net of tax are valued at £(1 + t) gross of tax; of each £1 of consumer spending, £1/(1 + t) goes to producers in wages, rents and profits and £t/(1 + t) goes to the government. Assume that the government balances its budget. Now suppose the government increases its spending by £1, and wishes to finance this through direct taxation. To do this, it must raise direct taxes by *more than* £1, since the increase in direct taxation will imply a reduction in disposable income and hence a fall in indirect tax revenue. In fact, direct taxation must be increased by £(1 + t). Disposable income will then fall by £(1 + t). Since the proportion t/(1 + t) of all consumer spending goes to the government as indirect tax revenue, indirect tax revenue will fall by £(1 + t) × t/(1 + t), i.e. by £t. Thus the net effect on government tax revenue is £(1 + t) – £t = £1. The implication of this example is that each extra £1 spent by the government is equivalent to a £(1 + t) loss of disposable income by households.

4.5 This conclusion should not be interpreted as saying that resources have a different value when they are in the hands of the government than when they are in the hands of private consumers. The point is simply that we are using two different units of account. When we say the government spends £1, we mean that it spends £1 in terms of the factor-cost unit of account. The cost to households in terms of disposable income is £(1 + t), but this is in terms of the market-price unit of account. Each factor-cost unit converts into (1 + t) market-price units: this conversion rate (or its reciprocal, depending on which unit we treat as basic) is the indirect tax correction factor.

4.6 Nor should it be thought that this argument applies only to goods which are traded on markets. For example, suppose the government spends £1 million (in factor-cost terms) on a road improvement whose only benefits are savings in leisure time. Suppose these time savings have a value of x when measured in terms of individuals' WTP, as expressed in stated preference surveys. How great must x be in order for the road improvement to be worthwhile? The answer is £(1 + t) million. In other words, if we are carrying out a CBA and are using the factor-cost unit of account, the WTP measure of benefit must be deflated by the tax correction factor. Why? Because stated preference surveys use the market-price unit of account. When a person says that she would be willing to pay up to (say) £1 to save one extra hour of travelling time, she is saying that, in order to save that hour, she would be willing to forgo consumption goods which are worth £1 *at market prices*. The same information could equally well be expressed by saying that she would be willing to forgo consumption goods which are worth £1/(1 + t) at factor cost. It is simply an accounting convention of stated-preference surveys (when addressed to private individuals or households) that answers are expressed in the market-price unit of account.

4.7 In passing, one implication of the argument in paragraph 4.6 is that if the value of the indirect tax correction factor changes between the date on which WTP survey data are collected ('time 1') and the date at which they are used ('time 2'), it is the latter value which is relevant for CBA. In effect, the survey data tell us that at time 1, a typical individual would be willing to give up a certain basket of goods in order to save an hour's travelling time. If preferences are assumed to have remained constant, then a typical individual would be willing to give up the same basket of goods at time 2. Thus, the value of WTP should be updated in line with changes in the general level of (post-tax) prices and then treated as if this value had derived from a survey carried out at time 2.

4.8 The distinction between factor-cost and market-price units of account must not be confused with the issue of whether the *relative* values which CBA assigns to different goods should correspond with relative pre-tax prices or with relative post-tax prices. It is a standard feature of CBA that relative pre-tax prices are used for evaluating changes in production, while relative post-tax prices are used for evaluating changes in consumption (see, e.g., *Principles of CBA*, pp. 99-112). It is only

under the special assumption (an assumption, it should be said, which will generally be used in this report) that the supply of every good is perfectly elastic that it is correct to use relative pre-tax prices as measures of the relative social costs of goods and services consumed in a project. Thus, a CBA which uses the factor-cost *unit of account* will not necessarily measure the social value of each good by *its* pre-tax price (i.e. by *its* factor cost). Similarly, a CBA which uses the market-price *unit of account* will not necessarily measure the social value of each good by *its* post-tax price (i.e. by *its* market price). Whichever unit of account is used, the *relative* social values of goods are the same. The adjustments which CBA has to make to reflect *differences* in indirect tax rates between specific goods will be considered in Section 5; these adjustments are not the same thing as the indirect tax correction factor.

4.9 The distinction between the two units of account is entirely separate from the distinction between the calculus of social costs and benefits and the calculus of WTP. In principle, CBA accounts can be drawn up using any of four (i.e. 2×2) different accounting conventions: either calculus can be combined with either unit of account. As explained in Section 3, which calculus is used should make no difference at all to the final results. Which unit of account is used should affect only the *scale* of the results: that is, every magnitude expressed in one unit of account should be the same multiple of the corresponding magnitude in the other unit of account.

4.10 There seem to be no compelling reasons to prefer one unit of account over the other. On the advice of DETR economists, this report uses the market-price unit of account. Thus, all magnitudes which are initially valued at factor cost will be multiplied up by the indirect tax correction factor $(1 + t)$. For comparison, the COBA formulae use the factor-cost unit of account, and so scale *down* all magnitudes which are initially valued at market prices.

5 Consistency between methodologies: impacts on indirect tax revenue

5.1 Because different goods are subject to different rates of indirect tax, changes in the pattern of consumer expenditure can have implications for the revenue that the government receives from indirect taxes. Such effects can be quite significant in the context of transport appraisals, because fuel (other than for public transport) is subject to very high rates of tax, while public transport services are zero-rated for VAT. Thus, switches of trips from car to public transport impose costs on the government in the form of loss of tax revenue. On the assumption that government expenditure and government borrowing remain constant, such a loss of indirect tax revenue must be made up by increases in direct or indirect tax *rates*, so that this cost ultimately falls on taxpayers.

5.2 A comprehensive CBA would take such effects into account when appraising projects. The

COBA methodology takes account of these effects through its distinction between 'perceived' and 'resource' costs. Indirect tax is a component of perceived cost, but not of resource cost. For example, suppose a road improvement induces an increase in the number of non-work trips made by car. The benefit of these trips is measured by users' WTP, which is expressed in terms of perceived costs. The cost of these trips is measured by their resource costs. So if expenditure on car trips is taxed more heavily than expenditure in general (as in fact it is), there is an element of net benefit corresponding with the government's increased tax revenue. (The treatment of indirect taxes in COBA is discussed in more detail in *Treatment of Taxation*.)

5.3 In contrast, the OPRAF methodology does *not* take account of differences in indirect tax rates. This is the relevant section of the *OPRAF Consultation Paper*:

> In practice, the Franchising Director is of the view that there are likely to be few instances where adjusting market prices for indirect taxes such as VAT would materially impact on the ranking of options. In addition, the taxes themselves may be there to offset an externality (the recent larger increases in fuel duty, for instance, have been part of the UK's strategy for meeting the CO_2 emissions target set at the 1992 Rio Summit). ... For these reasons, the Franchising Director's initial view is that it would normally be appropriate for costs and benefits to be valued at market prices, but he would welcome views on these proposals. Where appraisals involve the estimation of road user benefits he would expect such estimates to be consistent with the approach recommended by the Department of Transport at the time for appraising road schemes. (par. 4.10)

The *OPRAF Interim Guide* confirms this position: 'For most purposes, prices inclusive of direct and indirect taxes should be used in an appraisal' (par. 5.9). Thus the OPRAF methodology, if used with the market-price unit of account, uses actual market prices as measures of cost. Adapted to the same unit of account, the COBA methodology would in effect measure costs by adjusting the market price of each good to what it would have been, had it been subject to the economy-wide average tax rate.

5.4 Private firms are not expected to take account of the effects of their decisions on the government's indirect tax revenue. Thus, for example, a public transport operator, deciding whether to introduce a new (and unsubsidised) service, would be concerned only with whether revenue exceeded perceived costs. In fact, by attracting new consumers to a service which is zero-rated for VAT, the project would indirectly impose costs on taxpayers; but this effect would not be treated as relevant in a financial appraisal. Similarly, the Section 56 methodology ignores such effects when appraising a case for grant aid to a public transport project.

5.5 If, as the OPRAF *Consultation Paper* suggests, particular indirect taxes can be interpreted as payments in compensation for harmful external effects, *and if those effects are not directly taken into account elsewhere in the appraisal*, there is a case for treating those tax payments simply as costs in a

comprehensive CBA. It is difficult to see how the VAT zero-rating of public transport could be interpreted as a subsidy in respect of positive externalities which are not directly taken into account in a cost-benefit transport appraisal. But there is a strong case that some component of fuel tax should be interpreted as a charge for the environmental costs of CO_2 emissions. This raises the broader issue of whether the environmental effects of transport projects should be included, as far as possible, within the CBA framework, or whether these effects should be treated separately. Section 12 returns to this issue. Until Section 12, this report adopts the convention that environmental effects are dealt with *outside* the formal CBA framework.

5.6 As a general principle, it seems appropriate that a cost-benefit appraisal should include information about the impact of a project on indirect tax revenue. Such impacts are genuine costs or benefits, and are a matter of proper concern to public decision-makers. However, these impacts should be clearly separated from the direct public expenditure consequences of a project -- for two reasons. First, in the public accounts, an increase in expenditure is not equivalent to a reduction in tax revenue. Second, a decision-maker in a particular agency of government has a particular responsibility for *that agency's* budget; he or she should not be expected to be neutral as between a cost which falls on that budget and one which falls on government as a whole.

6 Consistency between methodologies: user benefits

6.1 A transport project creates *user benefits* to the extent that its users *would be willing* to pay for the improved services they are given and/or for the extra use they make of those services. (Conversely, a project can produce user disbenefits in respect of service worsenings. For simplicity, the following discussion is framed in terms of service improvements.) In a typical project, some of these user benefits are actually paid for by users. For example, if a public transport improvement induces an increase in trips with no change in fares, or if it allows fares to be raised without a reduction in trips, there is an increase in fare revenue which captures part of the increase in user benefit. Similarly, if a road improvement induces additional trips, some part of the increase in user benefit is taken up in increased expenditure on fuel. Typically, however, not all user benefits are actually paid for. There is also a component of *consumers' surplus*, i.e. benefits that users are in principle willing to pay for, but for which they do not in fact pay.

6.2 Where transport services are provided free at the point of use (as in the case of road space when there is no road pricing), the presence of this element of consumers' surplus is inevitable. Where services are priced, consumers' surplus exists to the extent that there is not perfect price discrimination (there is perfect price discrimination if each user is charged exactly as much as he or

she is willing to pay). Among the reasons why, in practice, price discrimination is never perfect are:

- *Competition*. In a fully competitive (or fully 'contestable') market, price discrimination is not possible because of the opportunities for 'cream-skimming' by new entrant firms (i.e. supplying only to those consumers who are willing to pay the highest prices, but undercutting the prices charged to them by existing firms). The more competitive the market, the less scope there is for price discrimination.

- *Administrative costs*. The more complex a pricing system is, the more costly it is to administer. (For example: long-distance train operators use pre-booking of return trips as a method of price discrimination; this requires additional time to be spent by booking clerks and ticket inspectors, and reduces the flexibility enjoyed by passengers.) In the future, improvements in technology (e.g. the use of smart cards) may reduce the administrative costs of price discrimination; but currently, sophisticated price discrimination is probably not feasible for urban public transport.

- *Regulation.* Regulators may not allow some of the more aggressive forms of price discrimination (e.g. by requiring certain standard, network-wide ticketing arrangements).

6.3 Because price discrimination in practice is far from perfect, user benefits are not fully captured as revenue, even when transport services are priced. A comprehensive cost-benefit appraisal would include all user benefits, irrespective of whether they were captured as revenue or enjoyed as consumer surplus. COBA is a comprehensive appraisal method in this sense.

6.4 The Section 56 appraisal methodology treats user benefits very differently. Under the Section 56 rules, the user benefits of a public transport project are measured by the additional revenue that the project generates for its operator. Thus, any change in consumers' surplus is ignored. However, benefits *to non-users* are taken into account, and are measured by conventional cost-benefit methods. In practice, benefits to non-users are mostly in the form of reduced road congestion, and are measured using the COBA formulae.

6.5 The Section 56 methodology is an instance of what is sometimes called *restricted cost-benefit analysis*. Although restricted CBA has not been much discussed by economists, it is in principle a coherent and defensible response to a serious problem in comprehensive CBA. The problem is that in a mixed economy, private sector decision-making is carried out according to the criterion of profitability, not according to the criterion of CBA. It is true that under certain idealised assumptions (roughly: either perfect competition or perfect price discrimination, and no externalities) the two criteria would generate the same recommendations; but those assumptions are far from realistic. In reality, the two criteria are liable to produce different recommendations. One of the main reasons for

this difference is that CBA takes account of consumers' surplus while the profitability test does not. Thus, the same project might pass the CBA test if it were located in the public sector but fail the profitability test if it were located in the private sector.

6.6 Clearly, the government cannot undertake to subsidise every private sector project which passes the CBA test but fails the profitability test: to do so would be to move to a centrally-planned economy. But at the same time, governments do want to subsidise *some* unprofitable private sector activities on account of the social benefits that they generate. What should be the criterion for such subsidies, if not CBA?

6.7 Restricted CBA provides a possible answer to this question. It is based on the principle that subsidies are to be given only on account of benefits which are external to the market transactions in which a firm is involved. How the surplus generated by market transactions is divided between transacting parties is, on this view, a matter for them and not for the government. It is up to each firm to find the best way of capturing the surplus generated by its activities: a firm does not qualify for a subsidy by creating consumers' surplus for its own customers which it fails to capture. In contrast, a firm might qualify for a subsidy by, say, reducing the emission of harmful pollutants into the atmosphere, since this benefit accrues to people who are not trading partners of the firm. Seen in this light, the introduction of the Section 56 method in 1989 might be interpreted as a natural consequence of the privatisation of public transport.

6.8 However, the principles of restricted CBA are ambiguous when a firm's activities create external benefits *through the consumption of its product*. An important example of this case can be found in urban public transport, where the external benefit of road decongestion is created only by virtue of an increase in consumption of public transport. In order to generate this external benefit, it may be necessary to set fares at a relatively low level. Attempts by public transport operators to capture a greater share of user benefits in revenue may thus reduce external benefits. It seems perverse to offer subsidies to public transport operators for the creation of external benefits while expecting those firms to adopt pricing strategies which undermine the process which generates the benefits.

6.9 This problem was implicitly acknowledged in the Department of Transport Circular 3/89 which first set out the Section 56 methodology. This circular states that in order to qualify for a grant, a proposal must show:

> that the scope for fare increases has been fully explored, with a view to finding the option which minimises the requirement for public sector support, given that benefits to passengers ... are expected to be met through fares rather than by the taxpayer or chargepayer (par. 6(iii))

This passage encapsulates the view taken of user benefits in the Section 56 methodology: it is the responsibility of the public transport operator to extract as much surplus as possible, and government grants should not be used, even indirectly, to hold down fares. However, the passage quoted is immediately followed by the following qualification:

> Other options involving lower fares (and thus increased patronage) which might yield significantly higher benefits to non-users, exceeding the additional cost to the public sector, should be discussed with the Department [of Transport].

The qualification confirms that the appraisal criterion is the maximisation of the excess of non-user benefits over cost in terms of grant-aid (or perhaps that the ratio of non-user benefits to grant aid should exceed some cut-off level). It is recognised that, in relation to this criterion, it will sometimes be counter-productive for an operator to seek to capture as much surplus as possible. Nevertheless, the principle that user benefits are excluded from the appraisal is maintained.

6.10 It could be argued that the Section 56 methodology is not an adequate response to the problem of deciding how far to subsidise the consumption of private goods which generate external benefits. This methodology can be interpreted as an attempt to establish a level playing field as between firms in the transport sector and those in other sectors. The argument is that firms in other sectors do not qualify for subsidy on account of user benefits which are not captured in revenue, and so neither should firms in the transport sector. But the analogy is imperfect. The cases we are considering are ones in which a public transport operator is charging low fares as part of a public policy to create external benefits. In acting as an agent of government in this way, the operator is forgoing the normal commercial opportunity to capture as much consumers' surplus as he or she can. Thus, the usual argument for treating revenue as the measure of user benefit -- that firms have many opportunities to extract consumers' surplus and that it is up to them to find and exploit these opportunities -- does not fully apply.

6.11 It appears that in the light of its experience from 1989 onwards, the Department of Transport found some of the implications of a wholehearted use of restricted CBA to be unacceptable. From the outset, London Transport was deemed to be an exception by virtue of its dense network of routes and its network-wide pricing system, making it impractical for any one service improvement to be financed by service-specific fare increases. More generally, there seems to have been some unease at the inconsistency between the comprehensive CBA method used for appraising road projects and the restricted CBA method used for appraising Section 56 proposals. The principle of restricted CBA was watered down in the 1993 Circular to Local Authorities which required that applications for Section 56 grants should be accompanied by comprehensive CBA appraisals (although the role of these appraisals in the decision-making process was not explained).

6.12 It seems clear, then, that restricted CBA has been found to be too rigid for general use in appraising public transport projects. However, it is doubtful whether any government would now endorse comprehensive CBA as the sole criterion for public transport subsidy.

6.13 Public transport services are now mainly supplied on a purely commercial basis by private-sector firms without subsidy. For almost every such service, a 'project' which simply used public subsidy to reduce fares would pass a conventional CBA test. Indeed, if a project of this kind reduced fares only slightly, it might be expected to have a very high benefit-cost ratio. (Consider the theoretical case in which a firm faces a downward-sloping demand curve and charges a profit-maximising price. If the relationship between price and profit is smooth, the rate of change of profit with respect to price must be zero at the profit-maximising price. But if price is greater than marginal cost, the rate of change of social benefit with respect to price is strictly negative. Thus, for a marginal reduction in price, the benefit-cost ratio -- i.e. the ratio between the change in social benefit and the cost in terms of subsidy -- is infinite.) If the government does not wish to subsidise fare reductions throughout the commercial public transport industry (not to mention subsidising price reductions elsewhere in the economy), it cannot use comprehensive CBA without reservation. Nor (as the example given in this paragraph shows) can it simply adapt CBA by using a cut-off benefit-cost ratio to shadow-price public funds.

6.14 The *OPRAF Consultation Paper* proposed a methodology which represents an intermediate position between restricted and comprehensive CBA. The formal appraisal framework proposed by OPRAF is a comprehensive CBA. The 'ranking criterion' for projects is 'present value of net benefits per pound of OPRAF support', i.e. the conventional benefit-cost ratio. However, the use of this criterion was to be constrained by the following principle:

> In general, the Franchising Director would expect users to pay for the benefits they receive from improvements to services. He would not therefore expect to pay more in support than the value of the net non-user benefits, except in material instances where revenue is a poor indicator of user benefits. Nor would he expect to pay more in support than the sum sufficient to secure the project. Where fares are regulated under Franchise Agreements, the Franchising Director will wish to consider the case for fares increases above regulated levels to reflect quality improvements above existing standards. (par. 3.12)

Thus, in order to be approved, a project would have to satisfy three criteria. First, net benefit (including user benefits) per unit of subsidy must exceed some cut-off level, presumably significantly greater than one (for comparison: London Transport uses a cut-off level of 1.6). Second, after excluding user benefits, net benefit per unit of subsidy must be no less than one (except in special cases). Third, there must be no net benefit, in excess of normal profit, to the operating company which receives the subsidy. This combination of criteria allows user benefits to *contribute to* the case

for a subsidy while not allowing them to *constitute* that case -- unless there are special obstacles in the way of capturing user benefits in revenue. These criteria also have the effect that, other things being equal, a project is more likely to be approved, the greater the extent to which user benefits are captured as revenue. (If user benefits can be captured without loss of economic efficiency, this reduces the subsidy requirement while leaving net social benefit unchanged.)

6.15 OPRAF's 'expectation' that user benefits should normally be paid for, and measured by, changes in fare revenue aroused a good deal of concern in the subsequent consultation exercise (*OPRAF Interim Guide*, Annex A, par. 10). In the *OPRAF Interim Guide*, the proposed criteria are revised. As before, the principal criterion is net social benefit per pound of OPRAF support, but the requirement that non-user benefits should be greater than the OPRAF subsidy has been dropped. However, there remains some presumption against subsidising user benefits. Thus:

> The Franchising Director expects fares alone to remain the most commonly used indicator of user benefits but he is willing to consider fare options which trade off other benefits against financial returns, subject to affordability (*OPRAF Interim Guide*, par. 3.6).

A subsequent paragraph emphasises that exceptional fare increases can be allowed for franchise operators who invest to improve service quality (par. 4.6).

6.16 These various proposals can be seen as different attempts to come to terms with problems that are inherent in public decision-making about subsidies to private-sector firms. There seems to be general agreement that a distinction has to be made between a class of activities which potentially qualify for subsidy and a class of activities which do not. Further, it seems to be agreed that proposals that are *solely* price reductions, and which benefit only users, do not qualify for subsidy, irrespective of their benefit/cost ratios. But as yet there is no consensus about how user benefits should be treated in evaluating price reductions which serve as a means of generating non-user benefits (as when low public transport fares help to reduce road congestion). Nor is there consensus about how user benefits should be treated when evaluating new service proposals. Nor is it clear how far operators are expected to go in using fare revenues to finance new services.

6.17 Implicitly, there seems to be some notion of a 'normal' or 'fair' price (which may vary according to the quality of the service). It seems that a public transport operator who proposes a new service is not really expected to charge whatever the traffic will bear before qualifying for subsidy: a new service can properly be subsidised if it makes a loss when 'normal' fares are charged, provided it generates sufficient external benefit to justify the subsidy. Thus, the idea that simple fare reductions are not to be subsidised is interpreted in terms of reductions in fares below 'normal' levels. However, the concept of a normal price is not formulated explicitly, and does not fit easily with the logic of CBA.

6.18 It is clear that some fundamental issues of principle need to be resolved before we can have a defensible formal criterion for project selection. Theoretical investigation of alternative criteria would be very valuable. It would also be valuable to have an empirical investigation of the extent to which, on average, private sector investments generate uncaptured consumers' surplus, so that we could have a better sense of what constitutes a special case.

6.19 In the meantime, probably the best that can be done is to use an appraisal framework which is as transparent as possible, which exposes any trade-offs which have to be made, and which provides enough information to allow a decision-maker to take account of the various considerations which lie behind comprehensive and restricted CBA. This points towards the use of a balance-sheet presentation in which the distinction between user and non-user benefits, and that between revenue and consumers' surplus, are not hidden by aggregation. The outline of such a presentation will be sketched in Section 10.

7 Consistency between methodologies: 'equity' versus 'behavioural' values of time

7.1 One of the peculiarities of the COBA methodology is its distinction between *behavioural* and *equity* values of non-working time. In principle, the behavioural value of non-working time for any user is measured by his or her WTP for reductions in travelling time. In practice, behavioural values are estimated for broad classes of road-user, differentiated by income, mode of travel, etc. The equity value of non-working time is the national weighted average of these behavioural values. (It is 'travel-weighted': the weights come from the National Travel Survey.) Behavioural values are used to predict changes in travel patterns. However, the cost-benefit analysis itself uses equity values.

7.2 If the COBA methodology were applied to cases in which benefits could be captured in revenue, the perverse case could arise in which trips were deemed to be worth less to the people who make them than they actually pay for them. For example, imagine a proposal to run a high-speed rail service from a city centre to a major airport. The operator of the service intends to charge high fares and to aim for a market of high-income passengers. The service would not earn quite enough revenue to cover its costs but it would generate external benefits in road decongestion; the value of those benefits would be greater than the subsidy required by the operator. Using the Section 56 methodology, the subsidy is justified. But according to the COBA methodology, it may not be. Since the (non-work) time saved by rail passengers would be valued only at the equity rate, the external benefits of the project would be offset by a notional loss to its willing users.

7.3 The use of the equity value of time in COBA is contrary to one of the fundamental principles of CBA: that benefits are measured by willingness to pay. Inevitably its use within a CBA framework

leads to anomalies. That this is the case is clearly recognised in the *Common Appraisal Framework* report (Section 4.11), which treats the use of the equity value as an unavoidable political constraint. As noted above, the Section 56 methodology implicitly uses behavioural values of time when it uses fare revenue as a measure of user benefit. The OPRAF methodology explicitly uses behavioural values of time to measure rail user benefits (*OPRAF Consultation Paper*, par. 5.9; *OPRAF Interim Guide*, par. 6.3).

7.4 The inconsistencies associated with the equity value of time may have been masked by two fortuitous features of the cases to which COBA is applied. First, most applications of COBA assume a fixed trip matrix; in such cases, the behavioural value of time has no implications for individuals' choices of travel patterns and so differences between the two values of time do not show up in appraisals as anomalies. Second, since roads are not normally priced, user benefits are not captured in revenue; this reduces the practical significance of questions about how much users are *actually* willing to pay for benefits. But inconsistencies would become much more obvious if the equity value of time was used in the appraisal of transport projects in general. The development of a common cost-benefit appraisal framework provides an ideal opportunity to give up the equity value of time.

7.5 Related problems are created by another distinction in COBA: between *perceived* and *unperceived* private costs. Two components of the costs of a trip are treated as 'unperceived', even though they fall on the person who makes that trip. These components are non-fuel money costs of non-work car trips (e.g. depreciation costs) and accident risks. Accident risks will be dealt with in Section 8; the current discussion will focus on non-fuel costs. Perceived costs are used to forecast changes in travel patterns; the defining feature of perceived costs is that they are costs which, as an empirical matter, play a role in the best available forecasting model. Unperceived private costs, then, are costs which fall on the individual making the relevant trip, which are 'real' costs in an objective sense, but which, according to the best available forecasting model, do not influence travel decisions. In measuring changes in consumers' surplus, COBA treats the perceived cost of a trip as its price; changes in unperceived costs are then treated as if they were externalities.

7.6 One implication of this treatment of unperceived costs is that, at the margin, trips which an individual chooses to make are deemed to be a net disbenefit to him or her. Thus, projects which generate additional (non-work) car trips are debited with an item of disbenefit corresponding with the judgement that at least some of these are trips which are being made only because of the car-user's ignorance of his or her own affairs. Such a treatment of consumer choice is not consistent with the usual presumption in favour of willingness-to-pay as the standard of valuation. It is also inconsistent with the Section 56 methodology for much the same reasons that the use of the equity value of time is. For example, suppose that a private firm proposes to build and operate a toll bridge, which will

generate a marginal increase in non-work car trips. From the firm's viewpoint, these marginal trips are valued by the revenue that can be earned from them, i.e. by that part of user benefit that can be captured as revenue. From the viewpoint of COBA, these trips are a source of net user *disbenefit* rather than benefit.

7.7 The perceived/unperceived distinction clearly leads to conceptual problems. In practice, these are concealed because in the COBA presentations of costs and benefits, the item which represents the disbenefits of supposedly irrational or ill-informed decision-making is aggregated with the genuinely external effects associated with car trips. The anomaly would become more visible in a balance-sheet presentation of the kind proposed in this report.

7.8 A fully consistent WTP approach would define costs in terms of individuals' perceptions, and thus would ignore unperceived private costs. The possibility of adopting this convention in place of the perceived/unperceived distinction deserves further consideration. In the rest of this report, however, the COBA distinction between perceived and unperceived costs is maintained for the sake of simplicity.

8 Consistency between methodologies: accident costs

8.1 The COBA methodology treats accident risks as unperceived costs of travel. Thus, accident rates play no part in the forecasting of travel patterns or of modal choice. No distinction is made between deaths and injuries which are suffered by 'users' and 'non-users': all accidents are treated as if they were negative externalities of travelling. The costs attributed to accidents are notionally made up of three components: loss of output by those injured or killed; medical and support costs; and the 'human costs' of 'pain, grief and suffering' (Jean M. Hopkin and Helen F. Simpson, *Valuation of Road Accidents*, Transport Research Laboratory Report 163, 1995 [hereafter *Valuation of Road Accidents*]).

8.2 The fixed point for the COBA valuations of accident costs seems to be a decision made in 1988 to take the value of saving a fatality to be £500,000 in 1987 prices. This valuation was intended to include all three components of accident costs. The decision to use this valuation was informed by survey research into individuals' willingness to pay for risk reductions, but (as the roundness of the number suggests) £500,000 was not the direct implication of any single piece of analysis. The authors of *Valuation of Road Accidents* offer the following gloss:

> A considerable degree of judgement was used in deciding on this value, but it has received wide acceptance as a Willingness to Pay estimate of the value of preventing one fatal road accident casualty (p. 5).

The £500,000 value has subsequently been increased each year by the growth in GDP per capita.

8.3 Non-fatal accidents were given a willingness-to-pay valuation from 1993. The valuation of the human costs of non-fatal accidents was derived from survey research using the standard gamble methodology. This research did not investigate individuals' WTP for risk reductions in absolute terms, but instead sought to discover the *relative* valuations of risks of non-fatal and fatal accidents. The results were then used to scale down (or in some extreme cases, scale up) the previously-determined value of preventing a fatal accident casualty.

8.4 Because of this convoluted history, it is difficult to say whether the values of accident risks currently used in COBA are measured at factor cost or at market prices. The survey data which informed the 1988 decision to use the £500,000 value were responses by private individuals, and thus were expressed in the market-price unit of account. Since COBA uses the factor-cost unit of account, part of the 'considerable degree of judgement' involved in the 1988 decision *should* have been the scaling down of survey responses by the indirect tax adjustment factor. For the purposes of the rest of this report, it will be assumed that this adjustment was made.

8.5 The Section 56 methodology treats accident risks as *perceived* costs of travel. Accident rates to car-users are assumed to be constant per vehicle-kilometre for any given type of road. To see the implications of this approach, consider a public transport improvement which induces someone to switch from making a trip by car to making it by public transport. There is a consequent reduction in (statistical) accidents to car-users; but this can be interpreted as a reduction in accident risks *for that person*, and not for anyone else. Except in relation to those relatively minor accident costs which do not fall on the person who is at risk (or on his or her family), this risk reduction counts as a user benefit in the appraisal of the public transport improvement, and so is not taken into account under the Section 56 rules. However, since accident risks to pedestrians and cyclists are assumed to increase with (motor) vehicle-kilometres, a switch of trips from car to public transport typically induces a reduction in death and injury for pedestrians and cyclists, and since this is an external benefit of the public transport improvement, it *does* count in the Section 56 methodology.

8.6 The OPRAF methodology also treats accident risks to users as perceived costs, while treating changes in risks to non-users as external costs or benefits (*OPRAF Interim Guide*, par. 6.5).

8.7 Even if no distinction is made between user and non-user benefits, it still makes a difference whether accident risks are treated as perceived or unperceived costs. Consider again the example in paragraph 8.5, and assume that the public transport improvement is a reduction in travelling time. The user benefits of this improvement are fully measured by the change in consumers' surplus, and the measurement of this change makes no explicit reference to accident risks -- for the good reason that the accident risks *on public transport trips* have remained unchanged. The perceived safety advantages of public transport relative to car travel are just one of many factors which combine to

determine the demand function for public transport.

8.8 As in the case of the unperceived non-fuel costs of car trips (discussed in paragraphs 7.5 to 7.8), treating accident risks as unperceived is inconsistent with the usual presumption that the values in CBA represent individuals' willingness to pay. The possibility of switching to the convention of treating accident risks as perceived costs is worth considering. For the rest of this report, however, the COBA treatment of accident risks as unperceived costs is maintained.

9 A common cost-benefit appraisal methodology: adapting COBA

9.1 This Section summarises the COBA methodology and then shows how this methodology can be adapted so as to make it consistent with the principles set out in Sections 2 to 8. For comparability with later analysis, the valuation of accident costs is excluded from the presentation, although these costs are included in the scope of COBA as unperceived costs.

9.2 The COBA model is designed to compare a 'do minimum' scenario with a 'do something' one -- typically, the construction of a new road. The following magnitudes enter into the COBA accounts. They should be understood as measured in present value terms. The superscript i can take the value 0 (the do-minimum scenario) or 1 (the do-something scenario):

S^i: consumers' surplus, i.e. the excess of the WTP of road users (non-work trips) or their employers (work trips) over P^i, the perceived cost of trips. This is measured in relation to a demand function which relates the number of trips to the perceived cost.

F^i: fuel cost of trips, including indirect taxes.

N^i: non-fuel money cost of trips (e.g. depreciation), including indirect taxes. For work trips, both F^i and N^i are assumed to be perceived; for non-work trips, only F^i is perceived.

V^i: 'perceived' time cost of trips. For work trips, time is valued at the gross wage rate, interpreted as a measure of the marginal product of labour. For non-work trips, COBA uses the equity value of time, i.e. a travel-weighted average of WTP. For the reasons given in Section 7, it would be more satisfactory to use behavioural values. The formal analysis which follows applies irrespective of how time is valued.

t: average rate of indirect tax on final consumption (denoted by x_N in the COBA manual).

t_F: rate of indirect tax on fuel as a final consumption good.

$t_F N$: rate of indirect tax on fuel as an intermediate good.

t_N: rate of indirect tax on non-fuel money costs as final consumption goods.

$t_N N$: rate of indirect tax on non-fuel money costs as intermediate goods.

The distinction between the two definitions of indirect tax rates is significant, because VAT is levied only on final consumption, whereas duties are levied on all purchases of a good.

9.3 The COBA manual defines P^i, the *perceived cost* of trips, as:

$$P^i = F^i + N^i + V^i \qquad \text{(for work trips)}$$

$$P^i = F^i + V^i \qquad \text{(for non-work trips).}$$

R^i, the *resource cost* of trips, is defined as:

$$R^i = V^i + F^i/(1 + t_F N) + N^i/(1 + t_N N) \qquad \text{(work trips)}$$

$$R^i = V^i/(1 + t) + F^i/(1 + t_F) + N^i/(1 + t_N) \qquad \text{(non-work trips).}$$

Here $F^i/(1 + t_F N)$ and $N^i/(1 + t_N N)$ are respectively the fuel and non-fuel costs of work trips, valued net of the indirect tax paid by firms on these intermediate goods. Similarly, $F^i/(1 + t_F)$ and $N^i/(1 + t_N)$ are the fuel and non-fuel costs of non-work trips, valued net of the indirect tax paid by households on these final consumption goods. $V^i/(1 + t)$ is the WTP value of time, deflated by the indirect tax correction factor. The COBA approach assumes that fuel and other resources used in transport are in perfectly elastic supply; thus, for example, if a project leads to an increase in the use of fuel, this increase is assumed to induce an equal increase in the production (or import) of fuel, and not to induce any decrease in the use of fuel elsewhere in the economy. The COBA formulae for 'increase in net economic benefit' (ΔB^*: the asterisk is used to denote that benefits are valued in terms of the factor-cost unit of account) are:

$$\Delta B^* = (S^1 - S^0) + (P^1 - P^0) - (R^1 - R^0) \qquad \text{(work trips)} \qquad \text{(1a)}$$

$$\Delta B^* = (S^1 - S^0)/(1 + t) + (P^1 - P^0)/(1 + t) - (R^1 - R^0). \qquad \text{(non-work trips)} \qquad \text{(1b)}$$

The rationale for these formulae in COBA is framed in terms of the calculus of social costs and benefits. It is important to keep in mind that COBA uses the factor-cost unit of account, not the market-price unit of account which will generally be used in this report.

9.4 The benefit of a trip to the road user (or to his/her employer) is measured by WTP; this is equal to the sum of perceived cost (i.e the amount the user thinks he/she is paying) and consumer's surplus (i.e. WTP in excess of what the user thinks he/she is paying). Thus in the do-minimum scenario, the total benefit of all trips is $P^0 + S^0$; in the do-something scenario, it is $P^1 + S^1$. The net change in total benefit is $(S^1 - S^0) + (P^1 - P^0)$. In the case of work trips, this benefit is already

measured in the factor cost unit of account, since it is measured as WTP by firms. In the case of non-work trips, it is measured as WTP by households, which is in the market-price unit of account; this must be divided by (1 + t) to convert to the factor-cost unit of account. Resource costs, measured in the factor-cost unit of account, are R^0 and R^1 in the two scenarios. Thus $R^1 - R^0$ is the net change in total costs; this is subtracted from total benefit.

9.5 The formulae (1a) and (1b) can be re-expressed so as reveal more clearly their rationale in terms of the calculus of WTP. Using the definitions of perceived and resource costs, (1a) and (1b) may be expanded and re-arranged to give, for work trips:

$$\Delta B^* = (S^1 - S^0) + (F^1 - F^0)\, t_F N/(1 + t_F N) + (N^1 - N^0)\, t_N N/(1 + t_N N) \qquad (2a)$$

and for non-work trips:

$$\Delta B^* = (S^1 - S^0)/(1 + t) - (N^1 - N^0)/(1 + t) + (F^1 - F^0)\,[t_F/(1 + t_F) - t/(1 + t)] + (N^1 - N^0)\,[t_N/(1 + t_N) - t/(1 + t)]. \qquad (2b)$$

9.6 In terms of the WTP calculus, (2a) may be interpreted as follows. The first term measures firms' WTP for the additional benefits they receive from the project. Since firms' WTP is already in the factor-cost unit of account, no tax correction is required. The second and third terms (the *indirect tax revenue terms*) measure the net increase in the government's indirect tax revenue as a result of firms' changes in purchases of fuel and of non-fuel items. A fuller explanation of these terms is given in *Treatment of Taxation.*

9.7 There is a similar interpretation for (2b). In this formula, the first term measures road users' WTP for the perceived additional benefits provided by the project, converted into the factor cost unit of account by deflating by (1 + t). The second term measures changes in unperceived money costs to road users. Since N^0 and N^1 are measured in the market price unit of account, the (1 + t) deflator is applied. The third and fourth terms are indirect tax revenue terms; they measure the net increase in the government's indirect tax revenue as a result of changes in the distribution of road-users' expenditure. Notice that these terms are relevant whether or not the money costs of car travel are fully perceived, since tax revenue depends on consumers' actual expenditure.

9.8 These formulae can be converted to the market-price unit of account by multiplying through by (1 + t) to give, for work trips:

$$\Delta B = (S^1 - S^0)(1 + t) + (F^1 - F^0)\, t_F N(1 + t)/(1 + t_F N) + (N^1 - N^0)\, t_N N(1 + t)/(1 + t_N N) \qquad (3a)$$

and for non-work trips:

$$\Delta B = (S^1 - S^0) - (N^1 - N^0) + (F^1 - F^0)(t_F - t)/(1 + t_F) + (N^1 - N^0)(t_N - t)/(1 + t_N). \quad (3b)$$

9.9 It may be helpful to interpret (3a) and (3b) in the following way. For each item of expenditure, the corresponding net social cost (i.e. the negative contribution of this item to the value of ΔB) is equal to what the money value of this expenditure would have been, *at market prices*, if that good had been subject to the economy-wide average rate of indirect tax. Part of this net social cost is included in the change in consumers' surplus and/or (in the case of non-work trips) in the change in unperceived costs. The indirect tax terms in (3a) and (3b) represent the residual.

9.10 For example, suppose that the number of work trips is constant but, as a result of a road project, firms' expenditure on fuel for these trips increases. This change in expenditure, inclusive of the indirect tax paid by firms, is $(F^1 - F^0)$. The corresponding net social cost is $(F^1 - F^0)(1 + t)/(1 + t_F N)$. The division by $(1 + t_F N)$ removes the specific indirect tax on fuel, as charged to firms; the multiplication by $(1 + t)$ adds the economy-wide indirect tax rate. Part of this net social cost is a negative component of $(S^1 - S^0)(1 + t)$, the change in consumers' surplus to firms measured in the market-price unit of account. More precisely, this negative component of surplus is $-(F^1 - F^0)(1 + t)$. The difference between this component of the change in consumers' surplus and the net social cost is $(F^1 - F^0)(1 + t)/(1 + t_F N) - (F^1 - F^0)(1 + t)$, i.e. $-(F^1 - F^0)\, t_F N(1 + t)/(1 + t_F N)$. This is the second term in (3a), except with the sign changed because (3a) measures changes in net *benefit*.

9.11 As a second example, suppose that the number of *non-work* trips is constant but household expenditure on fuel for these trips increases. This change in expenditure, inclusive of the indirect tax paid by households, is $(F^1 - F^0)$. The corresponding net social cost is $(F^1 - F^0)(1 + t)/(1 + t_F)$. The division by $(1 + t_F)$ removes the specific indirect tax on fuel, as charged to households; the multiplication by $(1 + t)$ adds the economy-wide indirect tax rate. Part of this net social cost is a negative component of $(S^1 - S^0)$, the change in consumers' surplus to households. This negative component is $-(F^1 - F^0)$. The difference between this component of the change in consumers' surplus and the net social cost is $(F^1 - F^0)(1 + t)/(1 + t_F) - (F^1 - F^0)$, i.e. $-(F^1 - F^0)(t_F - t)/(1 + t_F)$. This is the third term in (3a), except with the sign changed because (3a) measures changes in net benefit.

9.12 Given the assumption that the relevant goods are in perfectly elastic supply, the general principle behind (3a) and (3b) is this: For any item of expenditure, the net social cost is equal to what the cost would have been, had the relevant goods been subject to the economy-wide average rate of indirect tax. Any difference between this net social cost and the cost falling on the purchaser (after the latter has been expressed in the market-price unit of account) is counted in the CBA as an impact

on the government's receipt of indirect tax revenue.

9.13 This general principle can be applied straightforwardly to the construction costs of road projects. The net social costs are the actual money costs, net of any indirect tax actually paid, multiplied by (1 + t), i.e. notionally charged the economy-wide average rate of indirect tax. This net social cost can be broken down into a component which is incurred by the agency or firm which pays for the construction, and a residual component which represents the impact on the government's indirect tax revenue. Where construction costs are borne by the Highways Agency, the gross-of-tax costs should be recorded as costs to that Agency. Since the Highways Agency pays VAT on construction costs, it can be treated as a proxy final consumer; its gross-of-tax payments are in the market-price unit of account, and so no further adjustment is required. Where construction costs are borne by private firms (e.g. when a firms' contribution to a road improvement is a condition for a planning consent), these costs are not subject to VAT, and so the payment actually made by the firm must be multiplied by (1 + t) to convert to the market-price unit of account before being recorded in the CBA as a cost to the firm. Notice that (given the mix of resources used) the net social costs of construction are the same whether they fall on the Highways Agency or on a private firm.

9.14 Using (3a) and (3b), it is possible to summarize the results of a COBA study in a balance sheet or spreadsheet such as the one shown in Table 1. Here the term 'sponsoring agency' is used for the agency of government which sponsors the project that is being appraised.

Table 1: Cost-benefit spreadsheet for a trunk road project

Net benefit to project users (excluding accidents)	x1
Net increase in indirect tax revenue	x2
Net benefit of change in accident risks for project users	x3
Net benefit of change in accident risks for non-users, and external effects of accident risks for users	x4
Total benefit	x5 = x1 + x2 + x3 + x4
Construction and maintenance costs (borne by sponsoring agency)	x6
Net present value	x7 = x5 – x6
Net benefit as ratio of cost	x8 = x7 / x6

9.15 On the assumption that the COBA distinction between perceived and unperceived costs is maintained, the value x1 in the spreadsheet corresponds with the first term in (3a) in the case of work trips and with the sum of the first and second terms in (3b) in the case of non-work trips.

9.16 The value x2 corresponds with the indirect tax revenue terms in (3a) and (3b).

9.17 If all accident risks are treated as unperceived, x3 and x4 correspond directly with COBA valuations, consistently adjusted so that they are expressed in the market-price unit of account. In the Table, accident risks have been disaggregated into these two components as a reminder of the questionable nature of the COBA convention that all such risks are unperceived. If accident risks were treated as perceived costs of travel, x1 and x3 would be the two components of a single measure of the change in consumers' surplus to project users.

9.18 The spreadsheet shown here uses a very coarse classification of costs and benefits. It separates the 'safety' and 'economy' aspects of the appraisal, in line with the criteria used in DETR's new approach to appraisal. It also separates the impacts of the project into those that affect road users, those that affect the sponsoring agency, and those that affect the government's tax revenue. Obviously, it would be possible to use finer classifications, depending on the concerns of decision-makers. In particular, 'benefits to road users' could be subdivided among trips made by different classes of user (e.g. work and non-work trips, different types of vehicle, different trip lengths, different income groups, existing and generated trips). The object at this stage is merely to set out the basic principles by which a COBA analysis can be re-expressed in terms of the calculus of WTP as a more informative balance sheet.

9.19 In practical terms, very little modification to COBA is required in order to generate the data required for a spreadsheet like Table 1. For the purposes of this paragraph and paragraphs 9.20 and 9.21, it is assumed that the only modifications to be made to COBA are (i) to convert from the factor-cost unit of account to the market-price unit of account and (ii) to convert from the calculus of social costs and benefits to the calculus of WTP. Obviously, further modifications would be needed if it were decided to substitute behavioural for equity values of time, or to treat the non-fuel money costs of non-work trips as perceived costs, or to treat accident risks to users as perceived costs, or if it were judged that the valuations of accident risks, as currently used in COBA, were already (and erroneously) in the market-price unit of account.

9.20 In thinking about how to make these two conversions to the output of COBA, it may be convenient to use the fact that the value of ΔB^* is the same whether it is expressed as (1a) or as (2a), and the same whether it is expressed as (1b) or as (2b). Thus, the right-hand side (RHS) of (1a) is equal to the RHS of (2a); similarly, the RHS of (1b) is equal to the RHS of (2b). Using these

equalities, the indirect tax terms in (3a) and 3(b) can be re-expressed in terms of COBA concepts as:

$$(F^1 - F^0)\, t_F N(1 + t)/(1 + t_F N) + (N^1 - N^0)\, t_N N(1 + t)/(1 + t_N N) =$$
$$[(P^1 - P^0) - (R^1 - R^0)](1 + t) \qquad \text{(work trips)} \qquad (4a)$$

and:

$$(F^1 - F^0)\,(t_F - t)/(1 + t_F) + (N^1 - N^0)(t_N - t)/(1 + t_N) =$$
$$(P^1 - P^0) + (N^1 - N^0) - (R^1 - R^0)(1 + t) \qquad \text{(non-work trips).} \qquad (4b)$$

In the RHSs of (4a) and (4b), the COBA magnitudes P^0, P^1, R^0, R^1, N^0 and N^1 are defined as in paragraph 9.2. These equations can be interpreted as saying that the change in indirect tax revenue (i..e the LHSs of the equations, and the x2 entry in the spreadsheet) is simply the difference between the money costs which actually fall on road users (whether perceived or unperceived, measured in the market-price unit of account) and the corresponding resource costs (also measured in the market-price unit of account).

9.21 One implication of paragraph 9.20 is that the x2 entry in the spreadsheet, i.e. 'net increase in indirect tax revenue', can be derived from COBA as a residual. The total benefit of a project, as recorded in the spreadsheet (i.e. x5), is equal to the total benefit as measured by COBA, multiplied by (1 + t). The x1 entry represents changes in consumers' surplus and in unperceived private costs, i.e. $(S^1 - S^0)(1 + t)$ for work trips and $(S^1 - S^0) - (N^1 - N^0)$ for non-work trips. These measurements of changes in surplus and in costs are just as in COBA, except that they have been multiplied by (1 + t) to convert to the market-price unit of account. The x3 and x4 entries are also as in COBA, multiplied by (1 + t). Thus the value of x2 can be arrived at by subtracting x1, x3 and x4 from x5.

10 A general cost-benefit appraisal framework

10.1 This Section extends the analysis of Section 9 so that it applies to any transport mode, rather than merely to road projects. It turns out that this extension requires only minor modifications to the analysis presented in Section 9. As in Section 9, the COBA distinction between perceived and unperceived costs, and the COBA convention of treating all accident risks as unperceived, are maintained.

10.2 The COBA methodology distinguishes between three elements of the user cost of travel: time cost (V^i), fuel cost (F^i), and non-fuel money cost (N^i); for non-work trips, non-fuel money costs are treated as unperceived. For a CBA of a public transport project (or indeed of a toll road), it is necessary to consider a fourth element of user cost: fares (or tolls). Expenditure on fares will be denoted by M^i and treated as a perceived cost; N^i will now denote non-fuel, non-fare money costs, and

will continue to be treated as unperceived. The rate of indirect tax on fares (which currently is zero) will be denoted by t_M when these are payments for final consumption goods and by $t_M N$ when they are payments for intermediate goods.

10.3 It is also useful to adopt a broader interpretation of V^i. This will now be interpreted to include money valuations of any perceived costs which influence individuals' travel choices but which do not correspond with money outlays. Thus, V^i may include behavioural valuations of punctuality, reliability, crowding, service frequency, the inconvenience of interchanges, and so on. It may also include WTP valuations of the private costs of accidents, if it is decided to treat accident risks as perceived costs. The distinction between money outlays and non-money costs remains important, because of the different implications of the two kinds of cost for indirect tax revenue. S^i continues to denote the excess of WTP over the perceived cost of trips, with fares now included in perceived costs.

10.4 At the theoretical level, expenditure on fares and expenditure on fuel are equivalent to one another, except that they are subject to different rates of indirect tax: both are perceived costs which correspond with money outlays. Because of this equivalence, it should be obvious that (3a) and (3b) can be adapted to give the following more general formulae for the increase in net economic benefit for work trips:

$$\Delta B = (S^1 - S^0)(1 + t) + (F^1 - F^0)\, t_F N(1 + t)/(1 + t_F N) + (M^1 - M^0)\, t_M N(1 + t)/(1 + t_M N) + (N^1 - N^0)\, t_N N(1 + t)/(1 + t_N N) \quad (5a)$$

and for non-work trips:

$$\Delta B = (S^1 - S^0) - (N^1 - N^0) + (F^1 - F^0)\,(t_F - t)/(1 + t_F) + (M^1 - M^0)\,(t_M - t)/(1 + t_M) + (N^1 - N^0)(t_N - t)/(1 + t_N). \quad (5b)$$

10.5 From the perspective of the calculus of social costs and benefits, it might be objected that expenditure on fares and expenditure on fuel *are* different, because the former is a transfer payment while the latter (net of taxation) is a real resource cost. But when this objection is translated into the language of the WTP calculus, all it amounts to is that ΔB, as defined by (5a) or (5b), does not include the financial impact of the project on whatever agencies or firms receive the fares paid. In fact, (5a) and (5b) include only benefits which accrue to users and benefits which accrue to government through changes in indirect tax revenue. The full cost-benefit balance sheet must include financial impacts.

10.6 As an illustration of how a cost-benefit balance sheet can be constructed for a public transport project, consider a proposal for an investment programme which will increase the speed, reliability and frequency of a rail service in an urban area. The rail service is run by a private firm. A property development company which owns the site surrounding one of the stations will make some

contribution to the costs, but in order to go ahead, the project requires grant aid from central government. The improvement to the rail service is expected to generate some trips that would not otherwise be made, to induce some travellers to switch from commercially-operated bus services (not operated by the same company as the rail service), and to induce some travellers to switch from using cars. These switches of mode will reduce road traffic flows, thus reducing the time costs of trips by car and bus. This effect will be slightly offset by the fact that the less congested roads will induce additional road trips, but when a new equilibrium is reached, there will be fewer car and bus trips than before the rail improvement.

10.7 The formulae (5a) and (5b) can be applied to each trip type (defined by origin/destination pair and by mode, i.e. rail, bus or private vehicle). Thus, the benefits of the project to transport users can be measured for each trip type (this measurement is given by the first term in (5a) and by the first two terms in (5b)). The effects of the project on indirect tax revenue can be measured by summing the remaining, indirect tax terms of (5a) and (5b) over all trip types.

10.8 A cost-benefit spreadsheet for this project is shown in Table 2. Rows 1 to 24 (i.e the rows corresponding with x1, ..., x24) constitute a conventional, comprehensive CBA using the calculus of WTP. The elements x1 to x6 are derived from the formulae (5a) and (5b), as explained in the previous paragraph. Rows 6 to 12 record the net benefits of changes in accident risks to users and non-users. Rows 13 to 24 complete the CBA by reporting financial impacts on the project operator, the project partner, bus operators, and the government agency.

10.9 Bus operators are affected by the project in two different ways. In the capacity of road users, they benefit from the reduction in road congestion. For the purposes of this example, it is assumed that the consequent benefits of time savings to bus *users* are not captured by bus operators through increased fares; these benefits are entered as x2. However, bus operators benefit from those time savings that are attributable to bus drivers and to the buses themselves; these are entered as x3. There is a corresponding allocation of the benefits of changes in accident risks between bus users (x8) and bus operators (x9). But in addition, bus operators are affected by the reduction in the demand for their product as a result of the rail service improvement. They lose revenue (- x14) but they may be able to make cost savings as a result of carrying fewer passengers (- x21). In a perfectly competitive market, these two effects would cancel out; this would then be a pecuniary external effect of the project.

Table 2: Cost-benefit spreadsheet for a rail project

Net benefit to transport users (excluding accidents):	
project users (rail)	x1
bus users	x2
bus operators	x3
other road users	x4
Total benefit to transport users (excluding accidents)	x5 = x1 + x2 + x3 + x4
Net increase in indirect tax revenue	x6
Net benefit of change in accident risks to:	
project users (rail)	x7
bus users	x8
bus operators	x9
other road users	x10
net benefit of change in accident risks to non-users, and external effects of risks to users	x11
Total benefit due to change in accident risks	x12 = x7 + x8 + x9 + x10 + x11
Net increase in revenue for project operator (rail)	x13
Net increase in revenue for bus operators	x14
Total benefits	x15 = x5 + x6 + x12 + x13 + x14
Construction costs borne by:	
project operator (rail company)	x16
project partner (development company)	x17
grant from government agency	x18
Total construction costs	x19 = x16 + x17 + x18
Net increase in operating costs for project operator	x20
Net increase in operating costs for bus operators as response to change in demand	x21
Total costs	x22 = x19 + x20 + x21
Net present value	x23 = x15 – x22
Net benefit as ratio of grant cost	x24 = x23/x18
Private net present value	x25 = x13 – x16 – x20
Private financial benefit-cost ratio	x26 = x25/ x16
External benefit as ratio of grant aid	x27 = (x23 – x1 – x7 – x25) / x18
Proportion of user benefit recovered as revenue	x28 = x13 / (x1 + x7 + x13)
Attribution of net present value by initial incidence:	
Net benefit to transport users (excluding bus operators)	x29 = x1 + x2 + x4 + x7 + x8 + x10
Change in accident risks for non-users	x30 = x11
Change in indirect tax revenue	x31 = x6
Net gain to project operator	x32 = x25
Net gain to project partner	x33 = – x17
Net gain to bus operators	x34 = x3 + x9 + x14 – x21
Net gain to government agency	x35 = –x18
Total	x36 = x29 + ... + x35 = x23

10.10 Rows 25 and 26 summarise the financial profitability of the project, as viewed by the firm which is applying for a grant; profitability is measured on the assumption that the grant is received. This information is important to decision-makers in the grant-awarding agency, since grants are intended to be no greater than is necessary to ensure that a project goes ahead. The grant should not be approved if the information in these rows indicates that the project will generate more than normal profits for the operating company.

10.11 Row 27 shows external benefit as a ratio of the cost in terms of grant aid. Here, benefits and costs are 'external' if: (i) they do not fall on the company which is sponsoring the project or on project partners -- in this case, the rail operator and the property developer; (ii) they do not arise out of market transactions which involve the project sponsor or project partners; (iii) they are not the grant aid itself. The logic of an old-style Section 56 appraisal would require that a project should not normally be approved unless the ratio of external benefit to grant aid was at least one. For the reasons set out in Section 6, that criterion seems far too rigid. Nevertheless, given that it is not government policy simply to subsidise fare reductions, one might expect decision-makers to look critically at grant applications with very low ratios of external benefit to grant aid.

10.12 Row 28 shows the proportion of user benefit recovered as revenue. Here 'user benefit' is benefit which is attributable to trips made on the project service, or on other public transport services run by the same operator. The significance of this categorisation is that if perfect price discrimination were possible, user benefits so defined could be fully recovered by the operator who is seeking grant-aid, while other benefits could not be recovered in fares. (This claim is supported by further argument in Section 11.) A low value for this ratio should not disqualify a proposal, but as in the case of a low ratio of external benefit to grant aid, it is a signal that the application needs to be looked at critically. Decision-makers might want to ask whether the operator could recover more of the user benefits in fares without significantly reducing external benefit.

10.13 Rows 29 to 35 attribute the net present value of the project to classes of economic actor, defined by their relationship to the project. Information of this kind seems useful in a summary description of the economic effects of a project, although it needs to be treated with care. It should not be interpreted as a description of the *distributional effects* of the project (i.e. the effects of the project on the economic welfare of different classes of person). These measures show only the first round of incidence of the effects of the project. These effects may be transmitted into other parts of the economy through successive rounds of pecuniary externalities. For example, the 'user benefits' of a transport improvement, although measured in terms of the consumers' surplus of transport users, may ultimately accrue to owners of land. (In the example of the rail project, the entry in row 33,

which attributes a share of net present value to the property developer, would be negative. Presumably, however, the property developer's reason for contributing to the project is that it generates a benefit to the company which is greater than the contribution. This benefit is a pecuniary externality: it appears in the CBA as part of user benefit, but transport users are not the final beneficiaries.)

11 The disaggregation of benefits

11.1 The spreadsheet approach exemplified by Tables 1 and 2 disaggregates benefits in various ways. Conceptually, at least three different kinds of disaggregation can be distinguished:

- disaggregation by *recipient* of benefit;
- disaggregation by *source* of benefit; and
- disaggregation by *nature* of benefit.

11.2 A disaggregation by recipients is relevant if one is concerned with the distributional impact of a project. For example, a decision-maker might wish, other things being equal, to give more weight to benefits which accrue to people with low incomes. Thus if bus-users have a lower average income than car-users, the decision-maker might want to give greater weight to benefits accruing to the former group. The kind of disaggregation presented in rows 29 to 35 of Table 2 provides some indications of the distributional effects of a project. However, for the reasons mentioned in paragraph 10.12, one must be cautious about attributing changes in consumers' surplus *to specific groups of individuals.* The final incidence of benefits may be very different from the initial incidence.

11.3 A CBA can generate much more reliable information about the disaggregation of benefits *by economic source*. Take the example of the rail project discussed in Section 10. In this example, there are increases in consumers' surplus on all three modes: rail, bus and car. A disaggregation by source would divide the total increase in consumers' surplus between the three modes. Such a disaggregation is significant if a distinction is to be made between user and non-user benefits. The increase in surplus on rail trips is directly caused by the rail improvement, and is a *user benefit* of the project. In contrast, the increase in surplus on the other two modes is directly caused by a reduction in road travel times, which in turn is caused by the greater attractiveness of the rail service; this is an *external benefit* of the project.

11.4 It is important to distinguish between the disaggregation of consumers' surplus between modes of transport (which is a disaggregation by source) and its disaggregation between groups of

users (which is a disaggregation by recipient). The *Common Appraisal Framework* report points out that if there is switching between three or more modes (or routes), the available data tell us only the net change in trips by each mode and not how many people switch between each pair of modes. Thus, it is not possible to attribute consumers' surplus changes to individuals classified by post-project mode (*Common Appraisal Framework*, Appendix E). This consideration is one of the reasons for the *Common Appraisal Framework* recommendation that consumers' surplus changes should be disaggregated into 'change in consumption' (the net increase in the market value of trips) and 'new user value' (the total WTP valuation of trips which are generated by the project under consideration) (Appendix A). This argument, although correct, has no implications for CBA practice if the disaggregation of consumers' surplus is by source rather than by recipient. Thus, the author of this report is not persuaded that the disaggregation proposed in *Common Appraisal Framework* is helpful.

11.5 When one price (or generalised cost) change induces changes in other prices (or generalised costs), there is a theoretically clear way to disaggregate the total change in consumers' surplus between goods. This is to consider the exogenous price change as a sequence of infinitesimal steps, such that at each step, the prices of other goods change endogenously. At each step, there is a change in consumers' surplus for each good, which can unambiguously be attributed to that good. The theory behind this method is presented in my paper, 'The measurement of consumers' surplus in practical cost-benefit analysis', *Applied Economics*, 1979, pp. 139-146. This approach (or strictly, a linear approximation to it) is already used implicitly in COBA and in most other transport CBA methodologies.

11.6 This approach allows a meaningful disaggregation of consumers' surplus between user and non-user benefits. Take the example of the rail project. Imagine that the rail operator is able to implement perfect price discrimination, and assume zero income effects. Consider the improvement in the rail service as taking place is a sequence of infinitesimal steps. At each step, the rail operator can extract all the increase in surplus in respect of trips which, *at that stage in the sequence*, are being made by rail. But the operator has no means of capturing increases in surplus in respect of trips by other modes. Thus, that component of the total change in consumers' surplus which is attributed to rail trips is a measure of the benefits that, in principle, are susceptible to capture by the rail operator.

11.7 As an example of the third kind of disaggregation, consider the question of what proportions of the user benefits of a service improvement take the form of time savings, price reductions, frequency improvements, reductions in accident risks to users (if these are treated as perceived costs), and so on. This is not a disaggregation by recipient, because the same users receive all these benefits. Nor is a disaggregation by source, because all these benefits are part of the consumers' surplus generated by a single economic activity, and are susceptible to capture by the same firm. It is a

disaggregation by the nature of the benefit received.

11.8 The logic of DETR's new approach to appraisal requires disaggregations of this third kind. A change in consumer's surplus which accrues to a single recipient and which derives from a single source may be associated with more than one of the appraisal framework criteria or sub-criteria. (For example, 'journey times' and 'journey time reliability' are separate sub-criteria of 'economy', while 'safety' is a separate criterion; but a comprehensive definition of generalised cost would treat travel time, service reliability and accident risks as different components of the cost of a trip.)

11.9 Whenever generalised cost can be divided into components, it is straightforward to disaggregate benefits into the same components, provided there is no change in the number of trips made on each mode or route. When there are such changes, the process of disaggregation inevitably involves a degree of arbitrariness. For example, suppose that a reduction in generalised cost is made up of a fare reduction and a reduction in travelling time; these reductions jointly induce an increase in the number of trips. If we measure changes in consumers' surplus by first considering the effects of the fare reduction and then considering the additional effects of the reduction in travelling time, we will end up with a different disaggregation of consumers' surplus than if we had considered travelling time first and the fare change second. In practice, however, such differences are likely to be very small. In any case, it is both natural and neutral to adopt the convention that changes in consumers' surplus are attributed to benefit categories in the same proportions as the corresponding changes in generalised cost. Thus if, for a given type of trip, the fare falls by 10p and travelling time falls by an amount which is valued at 30p, then 25 per cent of the resulting increase in consumers' surplus is attributed to the fare reduction and 75 per cent to the reduction in travelling time.

12 Reconciling CBA accounts with the new approach to appraisal

12.1 This final section considers how the spreadsheet cost-benefit presentation exemplified by Tables 1 and 2 might be fitted into DETR's new approach to appraisal, in which projects are evaluated in terms of a list of criteria and sub-criteria.

12.2 The first criterion in the appraisal framework is 'Environmental impact'. The six sub-categories of 'Environmental impact' refer to a range of external effects of transport projects, all of which in principle ought to be included in a comprehensive CBA, but which in practice have usually been excluded. The COBA-based framework presented in this report does not attempt to value environmental effects. By providing qualitative descriptions and quantitative but non-monetary measures of environmental impacts, the new approach to appraisal allows these impacts to be taken into account in decision-making. If in the future DETR were to develop a methodology for assigning

WTP valuations to environmental effects (for example, by use of contingent valuation, stated preference or standard gamble techniques), the range of CBA could be expanded.

12.3 The second criterion, 'Safety', corresponds with a category of benefits which are routinely measured in CBA. The current COBA methodology evaluates accident risks separately from other costs and benefits of projects. If accident risks to transport users are treated as perceived costs, these are a component of consumers' surplus which can be separated out using the method suggested in paragraph 11.9.

12.4 The third criterion, 'Economy', comprises the four sub-criteria 'Journey Time and Vehicle Operating Cost', 'Journey Time Reliability', 'Scheme Costs', and 'Regeneration'. The first and third of these sub-criteria refer to central components of any CBA of road projects. Journey time reliability, although not currently part of COBA, would be a component of a comprehensive definition of generalised cost, and so could be valued in the same way as changes in travelling time, i.e. in terms of changes of consumers' surplus.

12.5 In the context of a *common* cost-benefit appraisal framework for all transport modes, this particular partitioning of 'economic' impacts seems less than ideal. Generalised cost can combine many dimensions of the experience of making a trip, such as travelling time, crowding, the differential valuation of waiting and interchange time, frequency of service, and reliability; there seems no obvious reason to make reliability a sub-criterion of its own. Expenditure on fares and tolls, which is an essential element of any CBA of a public transport project, does not fit anywhere in the framework. There is no natural place in the framework for taking account of the impact of a project on indirect tax revenue. Nor does the framework allow the effects of a project on the finances of individual firms or government agencies to be separated out. A spreadsheet presentation of costs and benefits of the kind proposed in this report (and illustrated in Table 2) seems more useful as a summary of the 'economic' impacts of projects.

12.6 Most of the effects encompassed by the 'Regeneration' sub-criterion are pecuniary externalities of transport projects, which are already measured as changes in consumers' surplus to transport users. Of course, there are many reasons why decision-makers and citizens might be interested in the regeneration impact of a project, independently of its implications for the cost of travel, and so it makes sense to include descriptions of these impacts in an appraisal summary. Nevertheless, it should be made clear that these impacts are not *additional* to those included in the CBA.

12.7 In *Transport Investment, Transport Intensity and Economic Growth: Interim Report*, the Standing Advisory Committee on Trunk Road Assessment (SACTRA) argues that transport projects

can have regeneration or economic growth effects which are not captured in the usual measures of consumers' surplus to transport users but which, in principle, ought to be included in a CBA. This argument applies when, as a result of market power, firms are able to charge prices in excess of marginal cost. Increases in the output of such firms generate net social benefits. If this argument is reformulated in terms of the calculus of WTP used in the present report, it can be understood in the following way. A firm which has market power is able to set prices which are equal to marginal cost plus a *mark-up*. A mark-up is the private-sector analogue of an indirect tax. As explained in Section 5, changes in the distribution of consumer expenditure between goods which are taxed at different rates can have impacts on the government's indirect tax revenue. Similarly, changes in the distribution of expenditure between goods with different mark-ups can have impacts on the total profits of firms, and hence on shareholders' incomes. Transport projects create benefits over and above those measured by changes in consumers' surplus to the extent that they lead to a diversion of consumer expenditure towards goods with high mark-ups; these benefits accrue to firms as increases in profit.

12.8 While SACTRA's argument is correct, it is not clear that the impacts that it analyses are the ones that decision-makers, citizens or the authors of DETR's new approach to appraisal understand by 'regeneration'. It seems more natural to interpret 'regeneration' as a general increase in economic activity in a target area, whether or not this activity is associated with high mark-ups. And on this latter interpretation, the regeneration impacts of transport projects are better understood as pecuniary externalities.

12.9 The distinction between 'Economy' and the fourth criterion, 'Accessibility', may have a rationale in the specific context of trunk road appraisal, but it does not seem to be appropriate for an appraisal framework which is to be common to all transport modes. The three sub-criteria of 'Accessibility', i.e. 'Pedestrians and others', 'Access to public transport' and 'Community severance' refer to the impact of a trunk road project on travel by modes other than private motor vehicles (i.e. walking, cycling, horse-riding and public transport). These effects correspond with items in the 'Economy' category, and are distinguished from the former items only by the fact that they refer to different modes of travel. They would be measured in a comprehensive CBA in essentially the same way that COBA measures the 'Economy' items.

12.10 Of course, decision-makers and citizens may wish to separate certain specific aspects of accessibility from the more general measurement of a project's impacts on the costs of trips and on consumers' surplus. For example, a decision-maker who is concerned about social inclusion may attach importance to the ability of particular groups of individuals (e.g. the old, the young, the physically handicapped) to make particular kinds of trips, even if these trips generate relatively small

amounts of consumers' surplus. Thus, it may be appropriate for information about such specific aspects of accessibility to be provided separately in the appraisal framework, even though the values of the corresponding benefits are measured elsewhere in the appraisal framework.

12.11 The final criterion, 'Integration', is an assessment of 'the extent to which the proposal is integrated with land use proposals and policies and with proposals and policies concerning transport (all modes)' (*Guidance on the New Approach*, par. 8.23). This is not really a distinct category of effects, parallel with the effects encompassed by the other four criteria; it is a strategic overview of the project which presumably draws on the information included under the other headings.

12.12 Summing up, the new approach to appraisal uses a list of criteria and sub-criteria which in some respects is not well-suited to the appraisal of transport projects in general, as contrasted with the particular case of trunk road projects. Suitably adapted, however, this framework could be compatible with a cost-benefit methodology which measures some but not all of the impacts of projects. It could also be compatible with the aspiration to expand the scope of cost-benefit analysis as techniques are developed and refined.