



University of the
West of England

Opportunities for improving transport and getting better value for money, by changing the allocation of public expenditures to transport

An Exploratory Analysis for the
Commission for Integrated Transport

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Summary

Each potential area of transport spending contains better and worse projects. A method is used based on formal benefit-cost calculations, to assess whether there are net benefits to be gained from changing the allocation of spending by increasing the spending on the best projects and reducing it on the worst projects under each heading. Tranches of spending are ranked in order of usefulness, for each heading and in total, and the results can be applied whether the overall budget is increasing, reducing, or staying the same.

On the basis of available data (not always reliable) and assumptions, the conclusions are as follows.

1. **The first £2billion.** It is very apparent that the very best value for money at present is coming from spending on a large number of small, relatively cheap projects aimed at **local safety schemes, smarter choices, cycle improvements** and some **quality improvements to bus services**. This has often been noted before as an observation on isolated examples in specific areas, but it appears that there is a general pattern: spending on these schemes is not yet sufficiently 'on the agenda' in proportion to their potential benefit, or in other words spending on these is being displaced by poorer value, but higher profile, infrastructure projects. It is worth spending about £2b on these as a first claim on funds before any other expenditures give such good value for money. The calculated economic benefits from this £2b will be in the order of £10b to \$30 billion, as compared with benefits of £3b to £4b which would be available from average infrastructure schemes which pass current BCR tests.
2. **The next £2billion.** After this, the next best value for money according to the assumptions could be obtained from some remaining bus, cycle and smarter choices projects, one or two tram systems, the first tranche of spending on ISA, and the best of the Highways Agency schemes.
3. Spending at greater levels than this brings in the next tranches of spending on ISA, some local roads schemes, and more tram schemes. With some caveats, the bank of data from past benefit-cost appraisals suggest, at face value, that there is closer competition

among a mix of bus, tram, local road schemes, highway agency schemes and national rail schemes: under each head, there exist schemes which are better than the worst ones under other heads, and deserve higher priority. (A feature of the method used is that it leads to a balanced mix of expenditures in this way). Because the differences are finer than in the first tranche, they are more sensitive to adjustments made following a more critical assessment.

4. **Revision following assessment of methods and assumptions** Some of the above conclusions are overstated, and some understated.

- (a) *Available data are not entirely on comparable assumptions:* the benefits of road building are usually by comparing 60 years of effects against a presumed ‘without’ case; the benefits of smarter choices, local safety and cycle schemes often only take account of a smaller number of years, often ten, or even only one, compared against a ‘before’ rather than a ‘without’. On a comparable base the BCRs of road schemes would be lower or the BCRs of smarter choices, safety and cycle schemes would be higher. As against this, some work currently being undertaken by the DfT, but not yet published, is reported to be suggesting rather lower BCRs for cycle and safety schemes (albeit still high), though it has not yet been possible fully to understand why. Similarly, work by DfT for future carbon assessment has used significantly lower BCRs for smarter choices than those reported here, though these are for a more distant future year after other changes are assumed to have happened, and therefore not so relevant to decisions in the next few years. It seems to be the case at the moment that the DfT is minded to expect the net effect of all these factors to bring the BCRs of local safety, cycling and smarter choices policies down, whereas it seems to me that they are more likely to increase. Further technical discussions will no doubt help to clarify this.
- (b) *Road pricing* is more clear-cut. If it is implemented in the future it would have very substantial benefits itself, also raising money and making savings by reducing the warranted road expenditure now, while increasing the expected value of public transport expenditure and the incentive for the private sector to fund it.
- (c) The *absence of road pricing* combined with a *need to make improvements*, (as distinct from slowing down the pace at which congestion gets worse), and the legal *obligation to*

reduce carbon emissions, both have the same effect of increasing the value for money of smarter choices and public transport.

- (d) Changes in the *treatment of fuel taxation in appraisal*, now agreed, will reduce the value for money of those road schemes which induce much traffic, and increase the BCR of those schemes which reduce the volume of traffic.

Taken together, these factors all lead to **greater confidence in the content of the first tranche**, not less; they also suggest **increasing the role of public transport in the 'third tranche'** and **reducing the spending on roads**, compared with the summary above. It may be that the greatest proportional difference is made to the position of rail investments, which on face value, under current methods and assumptions, often score less favourably than highways investments, but the combined effects of the tax effects, and possibility of road pricing in particular seems likely to reverse this order.

The dominant considerations in the calculations made have been those aspects which are formally given a money value in appraisal, notably congestion, economic efficiency, accidents, health and consumer welfare. Carbon targets have only featured to the extent that a carbon value is included in the BCRs, where it typically has a small impact. Social objectives including equity and quality of life have not figured at all from a formal point of view, but of course remain as part of public policy more generally. It is notable that the shifts of resource allocation arising from the analysis here in general favour policies which contribute significantly to these important objectives, suggesting that the opportunities for a broadly-based consensus are possible.

Introduction

Objectives

This is one of a series of short, swift ‘think pieces’ commissioned by CfIT, aimed at developing policy advice about “*opportunities for getting ‘more for less’ and generally managing the contraction in public expenditure on transport in the best possible way*”. Its specific scope is as follows:

“Issues to be reviewed include:

- What is the value for money at the margin for different types of public expenditure on transport (i.e. which items have high benefit cost ratios)? This should cover both investment, and current expenditure on operations and subsidy.
- How does the VFM of schemes relate to existing or planned investment, provision or consumption levels?
- Based upon the evidence, where should spending be reduced to secure the least loss of benefit, and where might there be a strong case for spending to be increased? What is the approximate magnitude of additional net benefit that might be achieved by a redistribution of spending along these lines? “

Structure of this Report.

There are three main parts.

First, I outline the general theoretical approach which is used.

Secondly, I take the results of other people’s work (and indeed my own) at face value, uncritically accepting a whole set of results of appraisals that have been carried out for many sorts of projects, providing data in a format which can be used. This leads to a set of interim, but heavily caveated, quantitative conclusions.

Thirdly, I consider the main criticisms and potential faults in the results, focussing particularly on those which might cause systematic differences in the relative performance of different sorts of expenditures, ie which are biases rather than just random errors. This leads to an amended view of the conclusions.

Part One: The Approach Used

Theory

The approach is based on the proposition that there are curves relating benefit to expenditure under broad heads, as shown in Figures 1 and 2 (which are equivalent).

Figure 1: *Total* Benefits Related to Total Expenditure

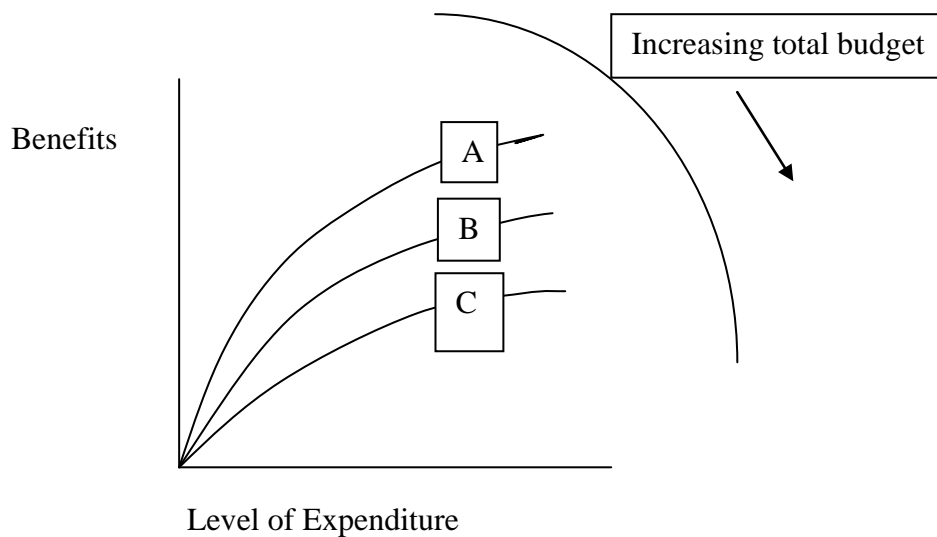
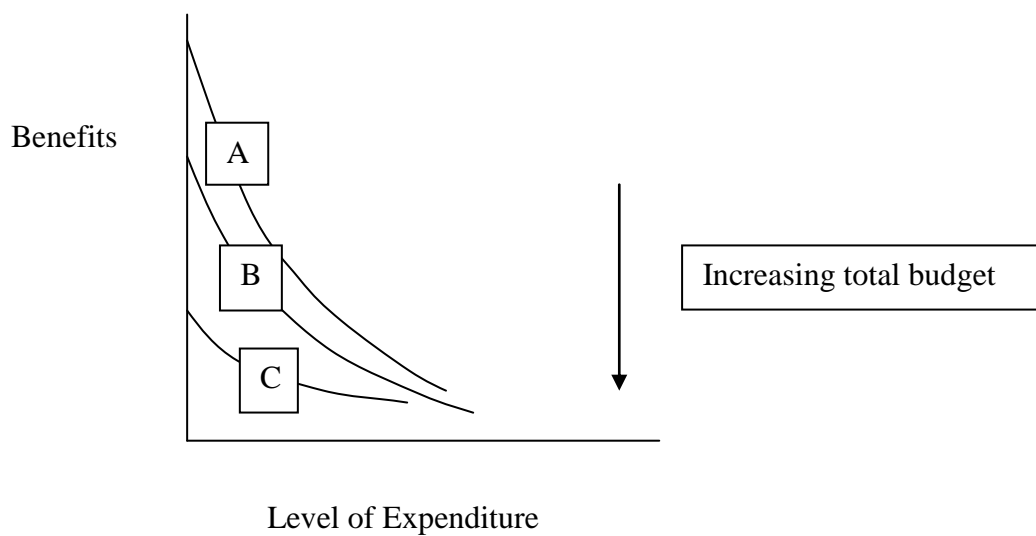


Figure 2: *Incremental* Benefits Related to Total Expenditure



In these figures, A, B and C are different types of expenditure, eg urban, interurban and international roads; or roads and public transport; or infrastructure and demand management; or expenditure on capital projects and revenue projects; etc.

Benefits increase with expenditure but with diminishing marginal return. The decision rule is to make the marginal return per £ spent equal for each type of expenditure, which will be where tangents to the curves are parallel to each other in Figure 1, or where the curves are cut by a line parallel to the X-axis in figure 2. In principle the total expenditure can then be read on a clock face in figure 1, or an additional Y-axis in figure 2 – or, in reverse, work backwards from a determined budget to the implied optimal allocation of funds¹.

It follows generally that the more is spent on a particular area, the lower the benefits, and hence that mature areas where expenditures have proceeded for a long time are likely to have lower average rates of return on the remaining projects, than new areas whose best has not yet been carried out.

Comparison with the Eddington Approach

The Eddington Report² had broadly the same objective as this study, especially in its Volume 3³. There are two main differences, partly of presentation (and the ease of policy analysis that follows from that), and partly of coverage.

Presentation and Policy Implications. In the main report several different forms of presentation were used to explain the results in graphs and tables, of which the most widely noticed presented estimated **mean** BCR for projects of a number of categories of interest, notably distinguishing urban/international gateway/interurban road networks, in some cases recognising variance around the means in the form of ‘box-and-whisper’ diagrams. Others have used similar presentations, for example Dodgson (2009)⁴ who provides a helpful overview of Eddington’s main results in the following table, together with his own headline summary comments, reproduced in Table 1.

¹ I do not know the origin of this graphical approach, but it is quite old – I was already writing about it as received wisdom over 40 years ago. (Goodwin P (1972) A simple visual solution of the technique of undetermined multipliers, *Mathematical Gazette* LVI 395, February 1972) so it is likely to be in economics textbooks of the 1960s eg by Allen or Baumol. It is odd that it has never been fully applied to transport as far as I know.

² Eddington R (2006) 'Transport's role in sustaining UK's Productivity and Competitiveness: The Case for Action'. Department for Transport, London
<http://www.dft.gov.uk/about/strategy/transportstrategy/eddingtonstudy/>

³ [Volume 3 - Meeting the challenge: prioritising the most effective policies](#)

⁴ Dodgson J (2009) Rates of return on public spending on transport, RAC Foundation, London
http://www.racfoundation.org/assets/rac_foundation/content/downloadables/rates%20of%20return%20-%20dodgson%20-%20190609%20-%20report.pdf

Table 1 Dodgson's (2009) Summary of Eddington Results

Sector	No. of projects	Ave BCR	Relationship between BCR and VFM categories				Total
			No VFM value	BCR & VFM the same	VFM > BCR	VFM < BCR	
Highways Agency Schemes	93	4.66	61	26	4	2	93
Local Road Schemes	48	4.23	5	39	2	2	48
Local Public Transport Schemes	25	1.71	9	11	5	0	25
Rail Schemes	11	2.83	11	0	0	0	11
Light Rail Schemes	5	2.14	2	2	1	0	5
Walking and Cycling	2	13.55	2	0	0	0	2
Total	184		90	78	12	4	184

Source: Table 1 of this report

With the exception of walking/cycling schemes, of which there are only two examples in the sample, average BCR values are highest for highway schemes (4.66 for Highways Agency roads, and 4.23 for local roads), next highest for heavy rail schemes (2.83), next for light rail schemes (2.14), and lowest for local public transport schemes (1.71). If light rail schemes were to be included in the local public transport category the average BCR would increase from 1.71 to 1.78.

It is possible that additional consideration of VFM could improve the position of local public transport schemes compared with road schemes because of the consideration of benefits that are not measured in monetary units.

Presentation of this sort lends itself to a certain type of mistaken policy conclusion, since simple statements of the form 'on average road schemes give better value for money than public transport schemes' (for example) can too easily⁵ be followed by 'therefore we ought to spend more on roads and less on public transport' (a conclusion that neither Eddington nor Dodgson made or even implied, without very careful and important caveats, Dodgson in particular drawing attention to an important problem of the way tax was treated in the analyses which is discussed further in Part 3 below).

In moving from average values to policy usefulness, it is necessary to compare not the average of each class of expenditure, but the best and the worst. Using the Eddington tables, one can do this on a scheme-by-scheme basis, and indeed DfT practice is mostly done at the level of specific schemes exactly in this way.

What this report does however is to try and develop a half-way house, or meso-level, between the macro-level averages and the micro-level schemes, so that broad classes of expenditure can be compared, but each categorised by a range of values not a single one. This is not at all inconsistent with the underlying logic of the Eddington analysis or the DfT appraisal

⁵ For example the RAC Foundation Press Release of 19.6.2009 launching Dodgson's report concluded: "overall there is little doubt highway schemes provide better value for taxpayer money than railway schemes. So why are ministers at the DfT ignoring this? Prejudice against road schemes needs to be put to the side"

principles⁶, but emphasises the strategic value for money at a budgeting level before focussing on a shopping list of schemes.

Coverage The Eddington study was provided with a very good data base of 141 road schemes, certainly good enough for statistical analysis and general conclusions, but was weaker on local public transport schemes (11), rail schemes (5) and was extremely impoverished on walking and cycling schemes (2, although these two had higher BCRs than any other category, which led Eddington to draw attention to their intriguing potential without being able to assert confidence in the result).

In any case, with only two schemes, a scheme-by-scheme approach could well lead to the conclusion that both of them should be carried out, but can say nothing about how much should be allocated in budgeting to schemes of this kind, since there is no knowledge of how many other opportunities for similar benefits might exist.

Therefore a main focus of this work is to seek to augment the relatively full coverage of road schemes, with comparable judgment about the availability of opportunities in the other areas.

Characteristics and Requirements of the 'Meso-Level' Approach

The approach is aimed at a strategic assessment of changes in expenditure at the margin, which requires looking for opportunities to move expenditure from poorly performing projects in one class to better performing projects in another, or (in the current economic context) seeking to make bigger cuts in the worst expenditures at the bottom of the list of each class, while safeguarding or increasing the more rewarding ones at the top.

The characteristic result is that in general it will be sensible to have some expenditure on all or several of the different types of project, starting with the best ones of each, not spend all the money on the one with the best average return. There is a prima facie hint, but no usable information, in the observation that the mean BCR of projects in one class is higher than the mean BCR of another class.

Although there is no presumption that decisions already made in the past will have been optimised, in general it is likely that the more mature the field of application, the more of the very best projects will already have been identified and carried out, so a mature class of expenditure may well have lower BCRs than it used to have, and lower also than new emerging fields. This does not mean that the new is always better than the old, but does mean that it is more likely to have unexplored potential.

For this approach to work, it is necessary to 'populate' the graphs with three indicators, and this is the main content of the following sections. They are:

the **mean** value of a benefit-cost ratio broadly representative of the whole field;

a **range** from the best to the worst expenditures, and the slope of its decline;

⁶ As, for example, was applied in the DfT assessment of effect of road pricing on value for money of road schemes, which is discussed in Part 3 below.

what I will call the *scope* ie how many worthwhile projects could actually exist in the real world if one had effectively unlimited funds, or, equivalently, what is the maximum amount of money that could find a place⁷.

National and local government funds are treated as interchangeable, as is capital and revenue spending. As far as possible, the calculation of what benefits are produced by £1 of public expenditure shows genuinely comparable numbers, but the profile of when they happen might be quite different, so that £1 spent out of the revenue account of a local authority and £1 spent as national government investment might both produce £2 of benefits, but in the first case they might all accrue in the first couple of years, and in the latter case it might take 60 years before they are fully produced, discounted to their equivalent current value. The recipients of those benefits will therefore also be different.

There are *many* potential complications, both theoretical and practical, some of which will be dealt with and others not according to how important they appear to be in the calculations, and the availability of information.

Data

The constraint that this exercise should be carried out and written up with ten days work over a period of about a month, subsequently extended by a few days to discuss and extend means it has to rely almost entirely on secondary sources, synthesising past technical work by others. In some cases however considerable manipulation was necessary to convert the data in the form required, which involved various more or less well supported assumptions.

The most useful sources are as follows:

The Eddington report, especially Volume 3, providing a substantial number of BCRs for specific road schemes distinguishing HA and local roads, and a small number of non-roads schemes;

Some additional information about each of the schemes kindly provided by DfT; A published, but less widely known, Annex , with further modelling analysis especially using the Department's National Travel Model;

An eclectic set of other reports giving information about areas where Eddington was weak or lacking, especially Rail schemes, Smarter Choices, Pedestrian and Cycling Schemes, Safety schemes, and some Public Transport projects.

Caveat: Specific Schemes and 'Grands Projets'

All the data used in the following section comes directly or indirectly from studies of real schemes, either in retrospective monitoring or forecast projections. Clearly, the whole exercise is also only useful to the extent that it will have something to say about real schemes

⁷ For example, suppose one is considering the benefits obtainable by equipping all vehicles with automatic speed control systems. The maximum total expenditure is that which equips 100% of vehicles, and after that, no matter how high the average benefits were, there is no point in spending any more.

in the future which should be supported, and others which should not. However, the level of geographically and technically specific analysis which has to be done for real scheme appraisal is at a different order of magnitude than the approach taken here: there are typically many volumes of reports and detail in the appraisal process. In addition, for a small number of very large schemes, there will often be decades of background, great political sensitivity, and a weight given to considerations like confidence and strategic centrality which are not included in BCR calculation anyway. Finally, the level of cost of one such scheme may be more than an entire class of other expenditure, and therefore has to be assessed on its own merits.

The approach taken here is to say nothing about the specifics of any of these few huge schemes – Cross Rail, for example – and also not to attempt to give a list of specific named smaller schemes for support or for abandoning. I entirely accept that this will be the ultimate significance of the approach, but suspect it may be easier to reach agreement on the general principles of the approach, and the shape of its conclusions, than to go immediately to the specifics.

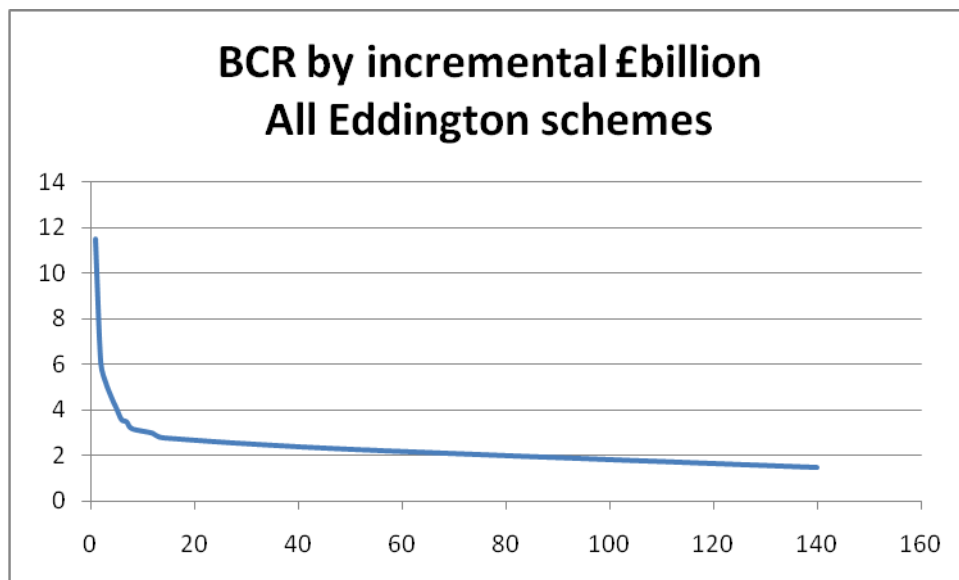
Part Two: Available Data, Reinterpreted as Marginal BCRs

In this section I mostly take published results uncritically at face value, only querying a few very implausible cases. At this stage I will avoid excessive repetition of caveats during the discussion, asking the reader to take the implications also at face value until tests of robustness are applied in Part 3.

Eddington Overview

Figure 3 shows 185 Eddington schemes, not distinguished by type, arranged in order of BCR, then with a simple average BCR calculated for each incremental £billion of expenditure (ie first considering the £1b of schemes with the best BCR, then the second billion, etc).

Figure 3 Incremental Benefit Cost Ratio for all Eddington Schemes



The immediate effect of arranging the results in this way is to see that there are a small number of schemes with very high BCRs, but the large majority show relatively little to choose between them. This suggests that at a time of financial stringency there will be good scope for identifying the few specific projects which are so good they should be safeguarded, but it will be more difficult to identify which of the many rather similar poorly performing projects should be rejected.

Thus the overall average⁸ of the quoted BCRs is 4.2. There are relatively few opportunities identified for BCRs better than 4, and then relatively little discrimination among a huge number of schemes with BCRs in the range 1.5 to 3.5. In this list, all the schemes found with BCRs better than 4 could be built with a total expenditure of less than £5b.

⁸ When I say average BCR, this is the simple mean of the BCRs of the category discussed. The mean of a set of ratios in general is not the same as the ratio of two means, and therefore this would not strictly be the same as the overall BCR if one did all those projects. It doesn't make enough difference to matter at this stage.

BUT the types of schemes populating this top rank are very limited because of the nature of the data base used – there were 64 road schemes in this top tranche, which may be taken as representing close to the entire population of road schemes having high BCRs and being technically feasible. (Of course, there could be many other poor schemes which nobody has bothered to design, but few which would be very good, but which nobody has yet thought of). In this high BCR top ranking group, there was only one walking/cycling scheme, and only four public transport schemes, and in these cases it is unreasonable to suppose that so few are a full population of all potentially excellent schemes that could be designed.

Distinguishing three major classes of scheme

In the Eddington data base, the two main classes of projects included are Highways Agency Road Schemes and Local Road Schemes for which a good population of studies was available. These are shown in figures 4 and 5.

Figure 4. Highways Agency Projects

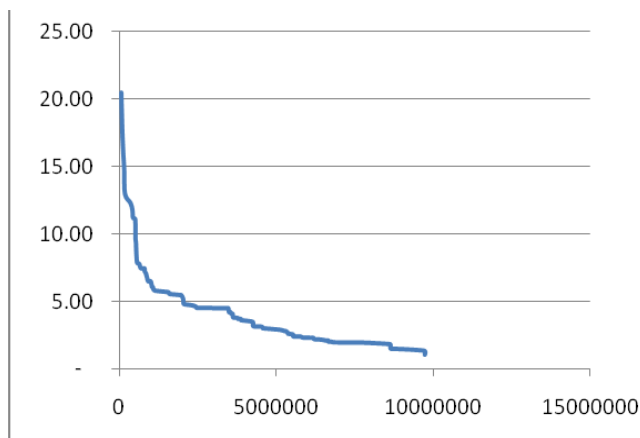
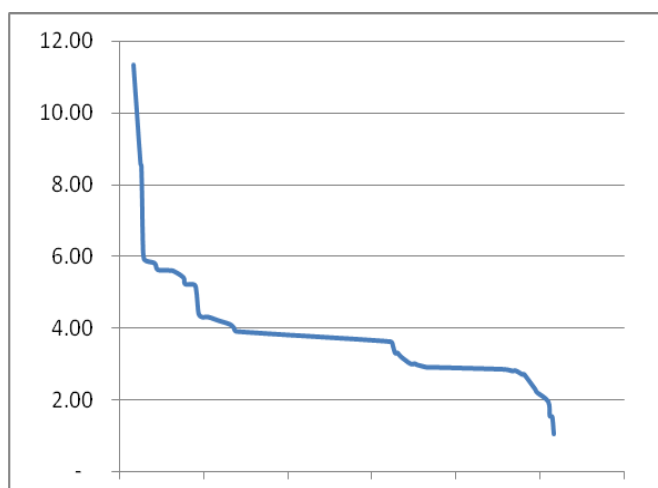


Figure 5. Local Road Schemes

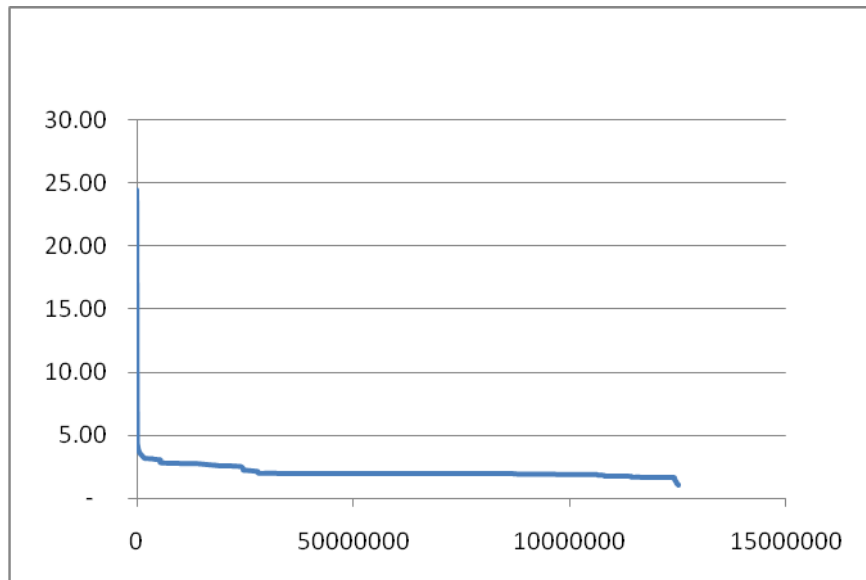


The Highways Agency schemes are (somewhat) more homogenous in character than the local road schemes, and therefore potentially give more insight into the generic nature of variation around a mean BCR for other (somewhat) homogenous classes. The DfT in its modelling

work did consider generically the potential for much more widespread increases in capacity over the whole network, and the implications of those results will be considered in Part 3.

Figure 6 then depicts all the other types of project listed by Eddington in the same format.

Figure 6. Eddington ‘all other’ schemes



The problem here is that the data base for other types of schemes is both very disparate – an unlike collection of a few walking and cycling schemes, public transport infrastructure, public transport subsidy, traffic management and miscellaneous schemes – and also much smaller in number than the road schemes, that is to say it is an under-populated distribution.

Leaving aside the sudden drop-off of data recording BCRs below an acceptable level, which is sensible given the waste of time to study and report such schemes in detail, it is still very puzzling that there is so little variation in the BCRs of most of the schemes. With a couple of exceptions nearly all the considered projects lie in the same narrow band of BCR, which happens to be just that level being close to the margin of acceptability for Government support. It is just not conceivable that this would be a representative reflection of the pattern of a well populated set of such unlike projects⁹.

Thus I propose to accept the Eddington schemes as an adequate population for Highways Agency and Local Road Schemes, but for all the others we will need to find other data.

⁹ It is common in the ‘negotiated’ management of cost benefit studies to seek ways of improving the calculated performance of rather poor projects, either by improving its design, which is a good thing, or by adjusting assumptions, which may not be. Similarly it can happen that there are pressures to reduce very high values for reasons of credibility or to seek official acceptance, especially with results which are so high as to cause doubt, potential controversy, costly policy implications, or are unfamiliar to critics.

Two Default Procedures

Where full information is not available, default assumptions are used in two cases, (a) to estimate the shape of the falling pattern of incremental BCR with expenditure, and (b) to estimate wider classes of benefit where only narrow ones have been calculated.

Default Relationship between Mean and Range

The Highways Agency scheme pattern shows a sensible relationship between the mean BCR and its variation over different levels of expenditure. This is shown by dividing the expenditure into tranches (quintiles is a convenient division), arranging them in order of value for money, and calculating an average BCR in each quintile. This is shown in Table 2.

Table 2 Variation of BCRs per quintile of expenditure for Highways Agency Projects

Expenditure on ranked schemes, best first	Average of BCRs in that tranche of expenditure	BCR/Average BCR rounded
1 st 20% of expenditure	10.4	2
2 nd	4.2	1
3 rd	2.9	0.6
4 th	2.1	0.4
5 th	1.5	0.33
Total	4.7	

(There are conveniently 98 schemes and £9.7b of total expenditure if all schemes were done, so each tranche is about £2b in this case).

The rounded version in the third column will be taken as a default assumption for the variance in BCR in cases where there is information on the mean or representative figure but no specific information on the range.

Note that this method is ‘cautious’ in the sense that it softens the effect of the very extreme values of the few highest performing projects. In all cases, the logic implies that there must be some egregious projects within the high average BCRs of the first tranche of expenditure, but proposing their existence by extrapolation is not the same as actually identifying them. Where they can be found special priority may be given, but at the stage of budgeting broad categories of expenditure some degree of averaging seems wiser. In any case, it should not matter if the best 20% of expenditure might be considered safe even in very stringent financial circumstances. There would have to be allowance for the likelihood that even in a rather poorly performing field, a few special projects could be outstandingly good.

Default Relationship between narrow and wider scope of BCRs.

There are important results in three case studies of ‘non-traditional’ types of projects given by the DfT in Webtag¹⁰ in the context of encouraging the wider application of appraisal using broadly consistent approaches as those used for road schemes. They are based on ex post analysis of three real cases, but their significance is probably more for the nature and scale of the effects than the specific schemes themselves. Benefits are estimated and given money values for health impacts, journey ambience, congestion, accidents, absenteeism, and environmental impacts

Scheme 1 – 1 km length of ‘greenway’ traffic-free pedestrian and cycling route

Public accounts costs 158086, benefits £3446671, BCR 21.8

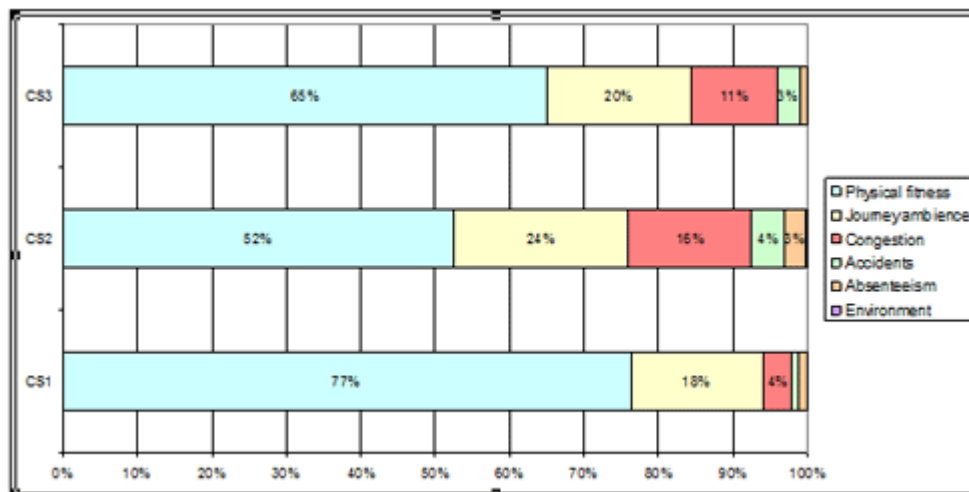
Scheme 2 – 6 km of canal towpath, access to an industrial business park

Costs £1911389, benefits £73474495, BCR 38.4

Scheme 3 – 1 new toucan crossing

Cost £230061, Benefits £4267478, BCR 18.5

The breakdown into different types of benefits for these schemes is shown in Figure 7



Proportion of benefits attributable to each sub-objective in each case study

Although the high BCRs are notably interesting in their own right, the relative importance of the different components is also useful for other similar types of projects, as discussed below.

We now proceed to consider alternative classes of expenditure, one by one.

¹⁰ <http://www.dft.gov.uk/webtag/documents/expert/unit3.14.php#05> April 2009

Smarter Choices

There are no overall BCRs for smarter choices carried out in the same way as for road schemes (ie formally modelled, with a 60 year time frame, tested against a do-minimum alternative forecast). The closest usable quantified indicator of performance is scheme expenditure per car kilometre removed from the network, based on before-and-after observation on an annual basis. Cairns et al (2004) report a mean of 1.5p per car kilometre, with a range from 0.1p to about 10p. This is converted to a congestion benefit by standard DfT marginal costs of congestion in different conditions, eg peak urban, off-peak urban, etc, itself with a mean of 14.6p per car km and a range in the relevant conditions from 2.1p per car km to 45p per car km. The overall average was therefore a congestion benefit of about 15p per 1.5 pence spent, or a ratio of 10.

Calculations carried out for ex post appraisal of the three Sustainable Travel Towns (Sloman et al, 2010 forthcoming) update this figure for inflation (coming to rather higher numbers but the same BCR) and also carry out a retrospective BCA of the effect in the three studied towns themselves, where the congestion benefit is assessed as rather lower, partly due to the policy context and objectives of the towns, partly due to their selection of a package of measures which were somewhat more expensive than the balance of measures proposed in 2004, and partly because the scale, duration and budget allocation were all less than the 10 year build-up assumed in 2004. Taking these into account, the ex post results suggested a BCR from congestion relief only (and excluding benefits from taking a proportion of those impacts in the form of extra mobility instead of less congestion, which was the policy context in one of the towns) of about 5.

In principle the (congestion only) BCR from different contexts of application, for different instruments, could range from about 0.2 to several thousand, but in practice the range is narrower because such measures are always implemented with a combination of the cheaper and more expensive instruments, and have effects over a mixture of different road types and conditions of congestion, so some of the theoretically possible variation will be averaged out. The range from a third of the average to twice the average shown in the HA results feels defensible to me.

Conversion from a congestion benefit towards a 'Webtag-like' benefit (as applied up to 2009, though see Part 3) can be done as follows.

- a) Smarter Choices' benefits are not only, or mainly, focussed on congestion, but also on health (to the extent that mode switches are to walking and cycling), environmental impact (from these, and also from any unmade trips and public transport transfers) and quality of life. Two of the three webtag guidance case studies above may be taken as representative of the relative proportion of congestion to total benefits for schemes with this sort of pattern of congestion, health, environmental, safety and wellbeing outcomes. This would mean multiplying the benefit by 7-9, say 8. This seems likely to be biased upwards. An alternative source for moving from congestion benefits to total benefits might be the results of the DfT assessment carried out for the Carbon Reduction Strategy. While the actual numbers are not comparable (since they were calculated for a version of 2020 in which a wide range of carbon saving measures were assumed already to have been successfully carried out, and hence imply much

lower carbon benefits from Smarter Choices than would be obtainable now), nevertheless it is of interest that even so the total estimated benefits were very close to double the congestion benefits, hence the BCR would be twice as great, ie multiplying the BCR by 2. Since this includes a reduced potential for carbon savings, it is likely to be biased downwards.

- b) In the form of analysis used in the Eddington BCRs, the fuel tax revenue generated by any induced traffic is treated as a reduction in the public expenditure cost of the schemes. By the same argument measures which are successful in reducing car use would have an extra cost of lost fuel tax revenue added to their cost. As a first approximation I assume this is a 6p cost per car km taken off the road¹¹.

Putting these together, we have average congestion-only BCR ranging from a (more-or-less optimised package) of 10, to an ex post achieved of about 5, multiplied by a maximum of 8 or a minimum of 2 to include other benefits. Taking figures half way between these maximum and minimum numbers, that suggests an average total BCR of 37.5, which under the old tax method would be drastically reduced to about 11 with a range, as above, from 22 for the best 20% of expenditure down to 3.7 for the fifth.

The next question is the scope, on the assumption that there is an upper limit to the number of Smarter Choices initiatives that can be undertaken, independently of their BCR. Here I take the 2004 report scenario of the intensive scenario of schemes which could be in operation at the end of a ten year build up. That didn't say but implied an expenditure of £750m per year nationally at 2003 prices, which is about 60% more than the rate of spending in the three current Sustainable Travel Towns (which were weak on certain of the full package of measures), so it is reasonable to treat this as the maximum scope at this stage. This puts the units of tranches of expenditure as £150m per tranche.

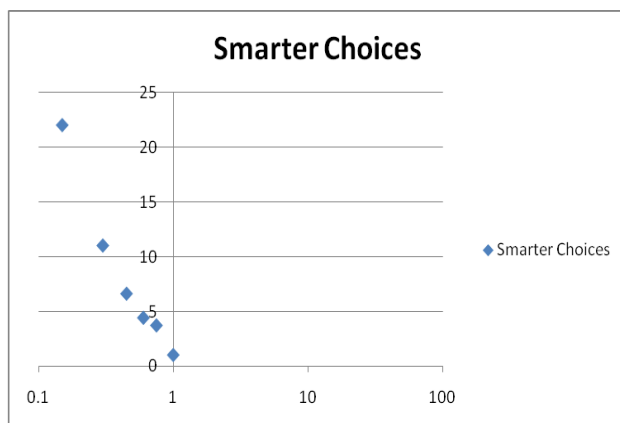
Thus the profile for Smarter Choices is as shown in Table 3 and Figure 8. (The figure excluding the tax effects would be an average about three times greater).

¹¹ I can't pass this by without commenting that this multiplies the cost of smarter choice measures by 3-5 – ie the lost tax revenue due to success is much greater than the actual cost of the measure itself, and gives Government a vested interest in not doing such projects, but favouring projects which generate more traffic. The results of the appraisals push in this direction even if such a policy orientation is rejected. It is a cause of great discomfort. Dodgson (2009) also drew attention to this problem, as have Buchan and other commentators. But in fact DfT has now decided *not* to use this form of calculation in future, so the more salient question will be the effects of the new method on all schemes, not just the effect of the old one on smarter choices.. Of course, if effects of schemes on traffic influence tax revenue, positively or negatively, that is a material policy question, will affect tax policy generally, and should be calculated and reported. But I agree that it is not appropriate to include it in actually in the BCR itself. The issue is further considered in the 'robustness' discussion in Part 3.

Table 3

Tranche of Expenditure (£150m)	Representative BCR for that tranche
1 st £150m	22
2 nd £150m	11
3 rd £150m	6.6
4 th £150m	4.4
5 th £150m	3.7
Total £750m	11

Figure 8



(Note that in these and following figures the X-axis, expenditure, is on a log scale, for convenience later when they are all put together)

These figures are high compared with most other classes of expenditure, which has raised some doubts. One point to make here is that a new field of application will in general still have the high potential of virgin territory, whereas in a more mature field (as most of the other areas are) there will have been many years history in which the best projects have already been done, reducing the average of the remaining ones.

Bus Improvements

I have used two main sources here. The first is a technical paper¹² by ITS Leeds and TSU Oxford as part of an exercise carried out by LEK for CfIT into value for money in the bus industry in 2002. This calculated BCRs for four different types of policy (fare cuts, frequency improvements, journey time reductions, quality enhancements) in seven different operating contexts (large medium and small radials, orbital, park and ride, interurban, and rural), using a 'narrow' and a 'broader' measure of social benefits. The overall mean BCR for the broad measure excluding three negative cases was 4.1, with a range up to 25. The biggest results being for medium quality enhancements though all the policies tested had BCRs over 2 for at least some of the seven contexts, thus frequency increases had the highest result for interurban services, fares cuts for the rural services, and so on.

The second source is web-posted summary results of a number of larger bus infrastructure schemes, especially busways, shown in table 5 overleaf. These show an overall BCR of 3.4 for schemes up to £88m in cost, even in quite small towns. This is not inconsistent with the 2002 results above, given that the scale is bigger and there may therefore be some drop off of benefit.

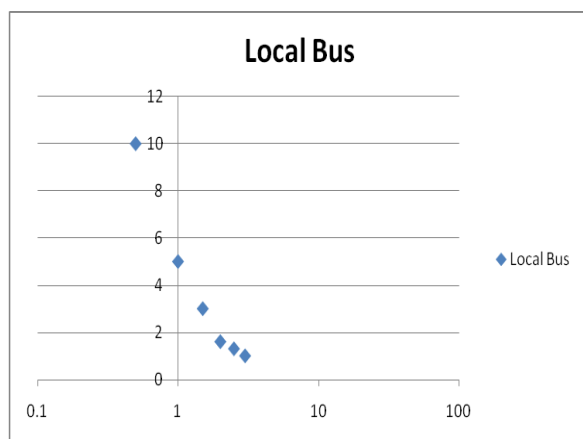
Taking these results together, it is notable that the mean and scale of bus schemes is very similar to those of local road schemes, with both cheap and expensive expenditures available over many different contexts not only large metropolitan areas, and quite high BCRs. This is not always the perception in policy discussion. There is a possibility however that the slope of the decline in value for money might be steeper, ie that one would 'run out' of good bus schemes to do more swiftly than one would run out of local road schemes with acceptable BCRs (especially if some of those road schemes were themselves oriented towards public transport improvements). Therefore while the mean and tranche size is taken as the same as for local road schemes, the ratio of tranche to mean starts higher and falls off more steeply. This is shown in table 4 and figure 9.

¹² Institute for Transport Studies, University of Leeds and TSU Oxford University (2002) Achieving Best Value for Public Support of the Bus Industry PART 1: Summary Report on the Modelling and Assessment of Seven Corridors. For main report and other papers see <http://cfrit.independent.gov.uk/pubs/2002/psbi/index.htm>

Table 4

Tranche of Expenditure (£0.5b)	Representative BCR for that tranche
1 st £0.5b	10
2 nd £0.5b	5
3 rd £0.5b	3
4 th £0.5b	1.6
5 th £0.5b	1.3
Total	4.1

Figure 9



Date	Scheme	cost	BCR	Reference
2005	Luton Dunstable busway	£88.3m	2.5	http://www.dft.gov.uk/pgr/twa/ir/lutondunstabletranslinkinspe1032?page=6#a1006
2008	Edinburgh bus priority A90	£700000	3.5	http://www.sestran.gov.uk/news/article.php?ID=42
?	Plymouth bus rapid transit	£14.5m	2.5	http://www.plymouth.gov.uk/ecs-chapter_7.pdf
2009	Wallsall town centre		6.85 revised down to 3.62 or 5 after cost increases	http://www2.walsall.gov.uk/CMISWebPublic/Binary.ashx?Document=7644
2004	Leigh Salford manchest busway	£43m	1.9	http://www.brtuk.org/downloads/BRTSymposiumUniversityofWarwick6-7thDecemberPresentations_09.pdf
2008	Tyne and Wear bus corridor	£15.3m	2.4	http://www.twpta.gov.uk/wps/wcm/resources/file/eb5f4d0a5ab5b91/8%20%20PTA%20report%20on%20MSBC%20%20as%20at%2015%20sept%2008.pdf
2007	Belfast bus priority	£3.03m	7.8 for best option (ordinary buses, unguided)	http://www.drdni.gov.uk/8_citi_quantitative_assessment.pdf

Local Safety schemes

The main source here is work by Evans in which he has reviewed other evidence and carried out his own analysis, summarised in a position paper for CfIT¹³. The convention in such studies is to give a first year rate of return only (rather than a net present value of an entire lifetime) and Evans assumes ten years of such benefits rather than the 60 of road schemes. This gave an average BCR (safety benefits only) of around 30, from an expenditure of £135m per year, even if there were no continuing benefits. The key question is how many opportunities there are to carry out such schemes over and above the ones that are already done. The impression is that there are many schemes currently not done for reasons of funding. Evans comments on the prima facie case that not enough is being spent on such good projects.

I make the assumption that there is a maximum potential of schemes of five times the current rate, that is before the incremental BCR falls to 1, but with a steep rate of fall. This is shown in Table 6 and figure 10.

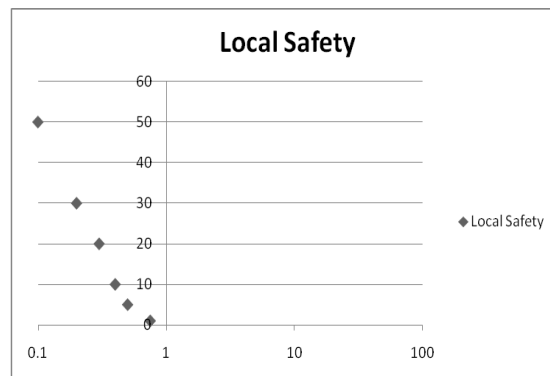
Table 6

Tranche of Expenditure (£100m)	Representative BCR for that tranche
1 st £100m	50
2 nd £100m	30
3 rd £100m	20
4 th £100m	10
5 th £100m	1
Total	>30

Some other work carried out by the DfT suggests an average BCR of the order of 13, somewhat less than half of the figure given here although still very high by comparison with many other areas of expenditure. I have not seen the technical basis of these calculations but discuss the implications in section 3.

¹³ Evans A E (2007) The economics of local road safety schemes: a position paper, CfIT

Figure 10



A National Safety and Traffic Management Scheme: Intelligent Speed Adaptation

The cases above have all been relatively separate initiatives in different places. A different type of application is the proposal to equip all vehicles with technologies enabling automatic or advisory speed adaptation to changing circumstances, with benefits that are seen mainly as safety and control of emissions. The main source used is work carried out by ITS Leeds¹⁴ for CfIT.

In this case, the scope is well defined – when all vehicles are equipped – and there is a single calculated BCR for the scheme as a whole. This varied according to different assumptions about the choice between mandatory and advisory approaches. The best case was a scheme costing £9.5b overall and giving a BCR for total implementation of 16.6. However that was for mandatory implementation which CfIT has not recommended. A purely advisory scheme was the worst performing, though even that had a BCR of 4.3. A BCR of 8.4 was given for a voluntary implementation, and this figure is close also to half way between a ‘market-driven’ and ‘authority driven’ approach, so it will be taken as representative here.

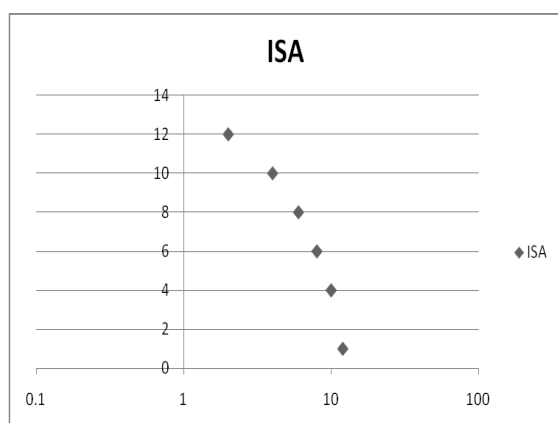
The question is what the nature of the BCR profile is for spending in phases, or for less than full implementation. Simulation suggested that benefits were broadly linear with market penetration (ie there is no evidence of a ‘critical mass’ effect before results are useful), but that does not imply that the BCR is uniform with expenditure, since there should be options to start market penetration with those sections of the market which are easier (hence cheaper) to engage, or with segments whose travel is disproportionately on types of journeys with higher accident costs. Therefore I assume an average BCR of 8.4, a maximum spend of £10b in increments of £2b, a cut off at 10b after which there are no further benefits to be had, and a rather gentle linear decline. This is shown on table 7 and figure 11.

¹⁴ Carsten O, Lai F, Chorlton K, Goodman P, Carslaw D and Hess S, (2008), Speed limit adherence and its effect on road safety and climate change, Commission for Integrated Transport

Table 7

Tranche of Expenditure (£2b)	Representative BCR for that tranche
1 st £2b	12
2 nd £2b	10
3 rd £2b	8
4 th £2b	6
5 th £2b	4
Total	8.4

Figure 11



Note that the results are expressed as though they were funded by Government. In practice it is likely that only a small proportion would be paid by Government, most coming from companies and individuals. While this does not change the basic appraisal of use of economic resources, it would mean that it becomes very much better value for money in terms of Government financial contributions.

Cycling

The main published source is a recent report¹⁵ giving early results of the Cycling Demonstration projects in six selected towns. This calculated a mortality benefit only of £2.59 per £1 spent. Therefore the question here is similar to the one for Smarter Choices and Local Safety schemes – how to make an estimate of the omitted benefits in a calculation where the cited BCR only includes one class of benefits, congestion in the case of Smarter Choices, traffic accidents in the local safety schemes and mortality here.

Provisionally I multiply by 2 to allow for other health benefits apart from mortality, and by 2 again to take account of the other categories of benefit (congestion, emissions) eg in the DfT Webtag case studies.

(I assume that the schemes chosen are accompanied by other measures or design criteria to ensure that an increase in cycling is not offset by an increase in accidents, which seems to have been the case in those towns: the cost and safety benefit of these measures would be treated separately as safety schemes discussed above above).

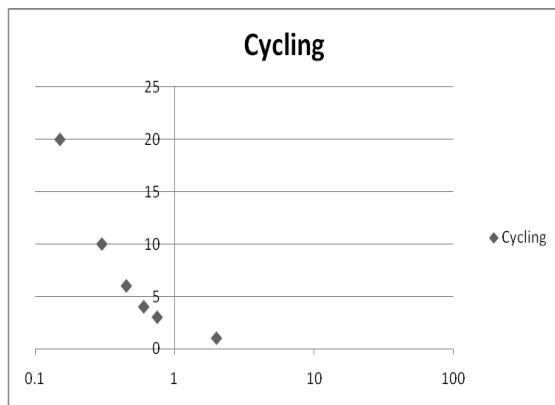
This gives an average BCR of 10.4. Then I apply the default ratios as above, and assume a maximum total spend of £750m per year before benefits fall to zero.

Table 8

Tranche of Expenditure (£250m)	Representative BCR for that tranche
1 st £250m	20
2 nd £250m	10
3 rd £250m	6
4 th £250m	4
5 th £250m	3
Total	10.4

¹⁵ Cavi N, Cope A, Kennedy A (2009) Valuing increased cycling in the Cycling Demonstration Towns, Department for Transport, December <http://www.dft.gov.uk/cyclingengland/site/wp-content/uploads/2009/12/valuing-increased-cycling-in-the-cycling-demonstration-towns.pdf>

Figure 12



Some current work by the Department for Transport is understood to suggest rather lower BCRs than the above, with the overall BCR suggested as being between 2 and 4, ie about the same as the above work estimated for mortality effects alone. The new work takes a ten year limit on the profile of benefits from cycling infrastructure, which *prima facie* seems odd given the 60 year profile for road infrastructure generally, and I think the DfT proposes that the benefit should be reduced for increased accidents to cyclists. (Cycle accidents did not increase in the cycling demonstration towns, but did not fall as much as elsewhere).

Rail

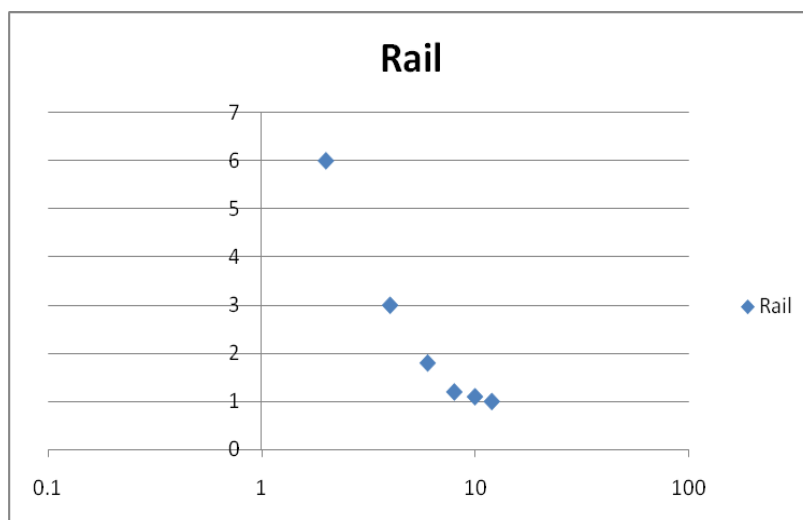
The 11 Eddington Rail Schemes mentioned above have an average estimated BCR of 2.83 (range 1.1 to 11) and the question is whether this is a large enough sample to be representative. Dodgson (2009) added a larger sample of 59 other schemes, up to April 2009, drawn from Network Rail Utilisation Strategies. I have not gone back to the original scheme appraisals, but using Dodgson's summary information one can calculate that the 59 have a BCR range of 1.1 to 9.2 and an overall mean (unweighted) BCR of 3.0. This is reasonably similar to the Eddington cases.

The separate scheme costs are not conveniently available in summarised form, but ranking the schemes by number instead of tranche of expenditure gives a pattern sufficiently similar to the default pattern above to suggest it might not be too wrong. A problem with treatment of rail is the lumpiness of a very small number of very large scale schemes. . As discussed, it is likely that in any schema a few such projects must be treated on their own and I ignore the specifics of (for example) Cross Rail as such a case.

I assume that cost of the list of 'ordinary' potentially worthwhile rail projects is in tranches of £2b, i.e. the same as for Highways Agency Road Projects (remembering that the 'Grands Projets' are ignored in this analysis) giving results shown in Table 9 and figure 13.

Table 9

Tranche of Expenditure (£2b)	Representative BCR for that tranche
1 st £2b	6.0
2 nd £2b	3.0
3 rd £2b	1.8
4 th £2b	1.2
5 th £2b	1.0
Total	3.0

Figure 13

I note at this stage that the BCRs of rail schemes may be particularly affected by the ‘modifications’ discussed in the Section 3.

Light Rail

(This is an experimental section using two quite different approaches, because of the big difference between the British view on this and many other countries, especially in Europe. I am wondering if there is something about the way we appraise urban light rail schemes which gives such different results).

Method 1 – examination of UK appraisal results.

As shown in table 1 above, Eddington had data on five UK light rail schemes, giving an average BCR of 2.14. This is not a sufficient sample on its own.

Dodgson cites a further 12 London Underground schemes with a mean BCR of 2.8, and 7 London Overground schemes with a mean BCR of 6.4. (Neither of these groups are light rail as understood in mainstream urban transport planning, though their urban role is somewhat similar). The range of BCRs for these 19 schemes was from 1.4 to 17.1.

Thus in the three groups of potentially relevant results, we have average BCRs of 2.1, 2.8 and 6.4 respectively, an overall unweighted mean of 3.7, albeit of rather unlike schemes and dominated by the London cases.

In recent years the UK has been much less active in developing, let alone building, light rail schemes than many other countries, but those other countries have typically been less interested in the UK style of cost benefit analysis, and such data on the assessment as exists is sparse and not easily collated. Thus it is of interest to consider an alternative approach.

Method 2 – examination of effects on property prices

It is now as common for sustainable urban transport policies, traffic reduction, pedestrianisation, and behaviour change to be led by trams as any other instrument. One experience that seems to be common between the UK and other systems is the observation of increased property values in the neighborhood of new tram systems. An alternative way into the question of benefits is to assume that the increased values is an internalisation of whatever benefits trams bring to neighborhoods. This would include any net effects of improved access and quality of life to those close to the systems, though would not include any benefits of reduced congestion to those living further away and travelling through it¹⁶.

The main source for this is a series of reports¹⁷ by Hass-Klau and collaborators from the consultancy ETP in Brighton and the University of Wuppertal in Germany. These collate before and after studies, and comparisons of areas with and without trams, in Europe, Western Europe, North America, and some other countries.

¹⁶ It also does not include effects that there might be of depressing property values in other areas without the benefit of the trams, if that occurs. This is an appraisal issue which would also apply to treatment of wider economic benefits of employment, efficiency, etc, where other areas may be relatively worse off as a result of improvements elsewhere, even if not actually worse off in a material sense.

¹⁷ A useful summary is in Hass-Klau C, Crampton G, & Benjari R (2004) Economic Impact of light Rail, Environmental and Transport Planning, Brighton

Results were a residential property price differential in 600 metre corridors (300 metres either side of a tram line) ranging from 3% to 20%, with a mean of around 13%. There is less strong evidence of a similar, though smaller and more variable, differential in commercial property also. Population densities within the 600 m corridors varied from 2500/sq km to 7000 /sq km, implying household densities of about a third of this, implying 500 to 1500 dwellings per kilometre of track,

Assuming a range of value per dwelling from around £80,000 to £1 m, a 13% average differential gives roundly £26m overall value premium per kilometre of tram line.

The cost per kilometre of tram route internationally varies from £3.7m to £18m. If we assume a typical value of £10m, this gives a mean internalised total value BCR from property prices of 2.6, ranging from close to zero to best cases in high densities and good property premium and low costs of about 20. This will include the amenity value of reduced traffic and associated environmental improvements, but not the decongestion value to people from outside the area, or carbon values. Perhaps we may cautiously round up to 4 for these factors¹⁸.

Comparison of the two approaches

Thus at face value the implied mean BCR of 4 in the property values method may be compared with a mean value of 3.7 from the appraisal results, which is sufficiently similar to give some added confidence in the results. There is an outstanding question about why UK urban tram construction costs are greater than other countries, which is unresolved, but meanwhile I take the lower figure, 3.7.

I then apply the default values for variation in BCR as discussed above, and assume a maximum potential of 50 schemes, with average 10 kilometres of route for each. Thus 500 km at £10m per km gives £5b total potential expenditure, assessed in increments of £1b. (This is a notional budget which does not include London Underground investment itself: it deals with new surface tram systems in urban areas, though of course London would be expected to qualify for an appropriate share in that notional budget).

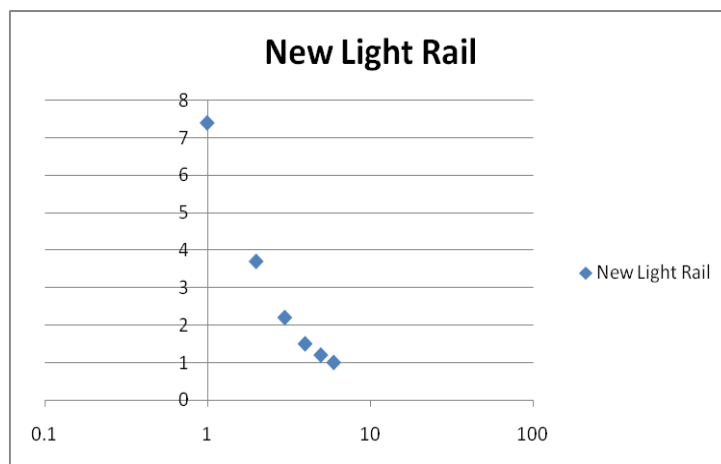
The range by tranche from 1.2 to 7.4 is broadly consistent with the appraisal results range from 1.4 to 17.1 allowing for averaging.

¹⁸ I record in passing that this calculation was done before examining any of the appraisal results cited under method 1.

Table 9

Tranche of Expenditure (£1b)	Representative BCR for that tranche
1 st	7.4
2 nd	3.7
3 rd	2.2
4 th	1.5
5 th	1.2
Total	3.7

Figure 13



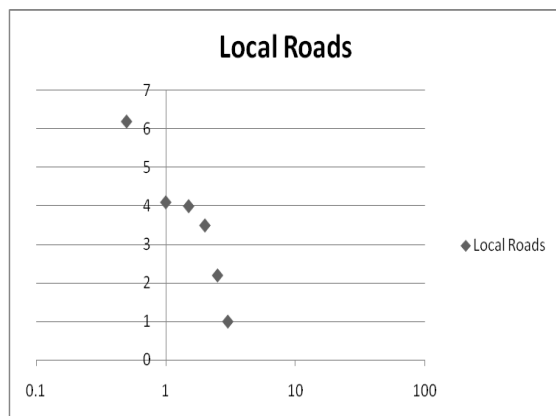
Local Roads

Figure 5 above gave the results directly from the Eddington data base for local road schemes. Here we replace them by a smoothed version in line with other projects, which has the indirect consequence that somewhat more discrimination is introduced into the variation than appears to be the case from study reports. (I think that this is probably more realistic anyway). Table 10 and figure 14 show these results.

Table 10

Tranche of Expenditure (£0.5b)	Representative BCR for that tranche
1 st	6.2
2 nd	4.1
3 rd	4.0
4 th	3.5
5 th	2.2
Total	4.1

Figure 14

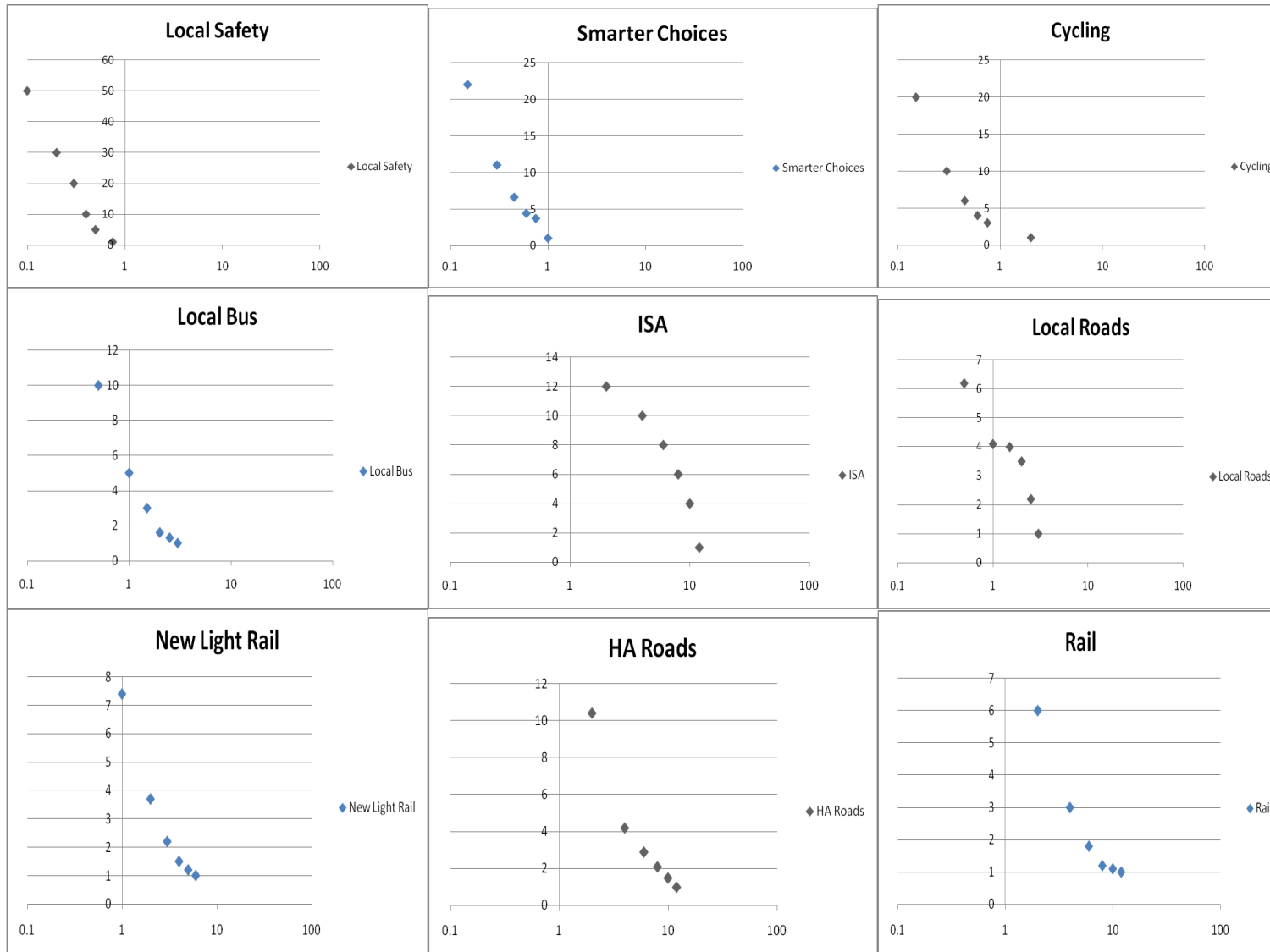


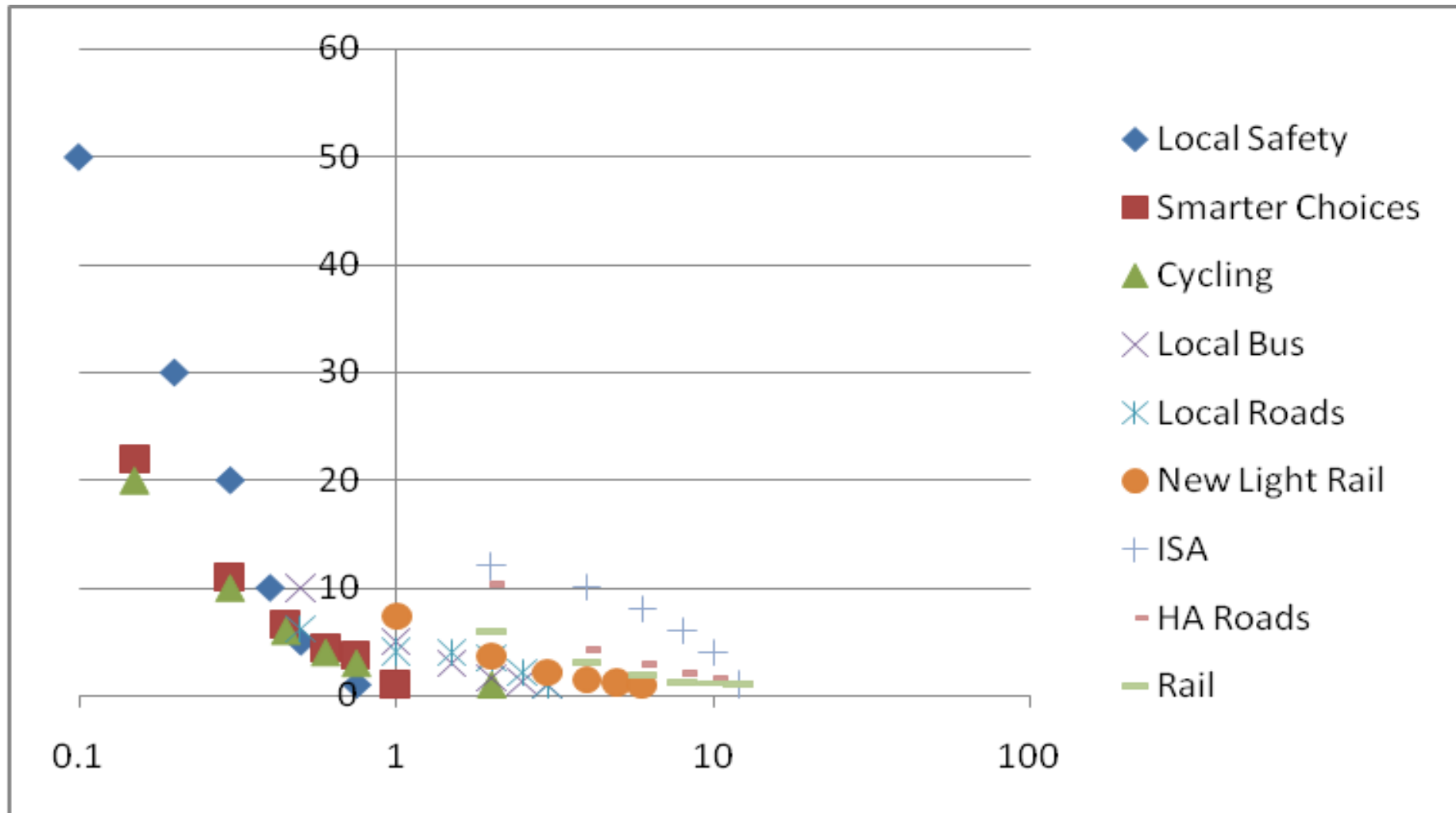
Synthesis of Results

Table 11 now put the results together, with figures 15 and 16 showing the collated results separately, and together, with the expenditure axis on a log scale. This completes the population of the marginal BCR curves, for the analysis carried out so far, and (repeating the earlier caveat) based on taking various agencies work at face value, mostly ignoring questions of inconsistency of approaches, and relying on default values and assumptions which all need to be treated with caution. The orders of magnitude of both Y-axis and X-axis values are then taken as first indications of relative value for money.

Table 11: Estimated BCRs by Quintiles of Expenditure for Nine Areas of Spending

Exp £b	Local Safety	Smarter Choices	Cycling	Local Bus	Local Roads	New Light Rail	ISA	HA Roads	Rail
0.1	50								
0.15		22	20						
0.2	30								
0.25									
0.3	20	11	10						
0.4	10								
0.45		6.6	6						
0.5	5			10	6.2				
0.6		4.4	4						
0.75	1	3.7	3						
1		1		5	4.1	7.4			
1.5				3	4				
2			1	1.6	3.5	3.7	12	10.4	6.0
2.5				1.3	2.2				
3				1	1	2.2			
4						1.5	10	4.2	3.0
5						1.2			
6						1	8	2.9	1.8
8							6	2.1	1.2
10							4	1.5	1.1
12							1	1	1.0





Conclusions

On the basis of the results and assumptions as discussed, the conclusions are as follows.

1. **The first £2billion.** It is very apparent that the very best value for money at present is coming from spending on a large number of small, relatively cheap projects aimed at **local safety schemes, smarter choices, cycle improvements** and some **quality improvements to bus services**. This has often been noted before as an observation on isolated examples in specific areas, but it appears that there is a general pattern: these schemes are not ‘on the agenda’ in proportion to their potential benefit, or in other words spending on these is being displaced by poorer value, but higher profile, infrastructure projects. It is worth spending about £2b on these as a first claim on funds before any other expenditures give such good value for money. The calculated economic benefits from this £2b will be in the order of £10b to \$30 billion, as compared with benefits of £3b to £4b which would be available from standard average ‘good’ infrastructure schemes.
2. **The next £2billion.** After this, the next best value for money could be obtained from some remaining bus, cycle and smarter choices projects, one or two tram systems, the first tranche of spending on ISA, and the best of Highways Agency and Rail schemes.
3. Spending at greater levels than this brings in the next tranches of spending on ISA, some local roads schemes, and more tram schemes. With some caveats, the bank of data from past benefit-cost appraisals suggest, at face value, that there is closer competition among a mix of bus, tram, local road schemes, highway agency and rail schemes: under each head, there exist schemes which are better than the worst ones under other heads, and deserve higher priority. (A feature of the method used is that it leads to a balanced mix of expenditures in this way). Because the differences are finer than in the first tranche, it is likely they will be more sensitive to adjustments made following discussion in Part Three.

Part Three: Gaps, Criticisms and Robustness

Gaps

There are omissions in the analysis so far. The most important are as follows.

Pedestrianisation and traffic calming.

Some elements of pedestrianisation are included in the results for Smarter Choices, and some elements of traffic calming are included in the results for local safety schemes, both of which show large benefits and good value for money. But there is a remaining gap in both cases.

Large scale pedestrianisation of town centres has probably been the biggest success story in transport planning internationally in recent years, being very popular (when well done and carefully planned), showing positive effects on business turnover, successfully overcoming initial political opposition, and being a significant part of all urban town centre regeneration strategies. I have not been able to find any significant body of research that can be described as close enough to conventional cost benefit analysis to produce BCRs, or even much interest in carrying it out. The retail turnover effects could potentially be used in a way analogous to the property price analysis used for trams, but are not currently available in a form suitable for easy analysis.

Traffic calming has also become ubiquitous, and the safety considerations have been perhaps the most influential element of that in the UK, but are not so dominant a consideration in European decisions where quality of the local neighbourhood, noise, play-streets and the like are often more persuasive. Public opinion surveys continually assert their popularity, though not for all the different instruments of calming, where speed bumps in particular can be unpopular.

There would be obvious harm if this report, by focussing on those areas where BCRs exist, should appear to downplay the importance of such successful policy instruments. Bearing in mind that the UK typically seems to have implemented pedestrianisation schemes at about half the rate of Germany (Hass-Klau, forthcoming), and traffic calming possibly a similar comparison with the Netherlands (or less), there is a *prima facie* case that current levels of expenditure are to be increased, not reduced, and it seems inevitable that the case for doing so will have to continue being discussed without access to conventional BCRs.

Maintenance

There is a similar issue for maintenance, in that many routine maintenance expenditure decisions are taken with an assumption of 'necessity' rather than 'costs and benefits'. Anecdotal evidence suggests that there is a strong view that it is more important at a time of financial pressure to protect maintenance budgets than new infrastructure.

In this case there does exist a literature of studies in some particular applications, but in the time available I have not been able to use and generalise it. Again the same caveat applies: its importance is not measured by the presence or absence of simple BCRs.

Concessionary Fares

The case of concessionary fares is quite different. There is a very large body of studies on the cost and effects of concessionary fares (much of it contested and involved in disputes between operators and authorities) but the focus of technical attention has been quite different. The major public expenditure issue is the cost of reimbursing operators for the revenue lost and extra cost incurred in providing services to concessionary travellers, primarily the elderly, and as a result much is known about the demand impacts. This tends to show that purely considered in terms of the bus journeys provided per £1 spent, concessionary fares have quite powerful effects, but because the expenditure rules make no distinction at all between bus users attracted from car, or walk, or making new induced trips, there has been no tradition of using BCRs, or even trying to calculate them. I am only aware of one study which sought to carry out a comprehensive analysis of the BCR of concessionary fares, but its key conclusions are not accessible.

Optimisation of expenditure within class

A different sort of omission is the consideration of optimisation of expenditure *within* each broad category. Some indications have emerged during the analysis, such as the relatively higher BCRs that have been found for workplace travel plans within smarter choices, or quality improvements that have been found within buses. It would be expected that they would behave in the same way as the analysis above, with the reservation that, in these cases, it is likely that a package including different aspects will be necessary in order to create coherent travel opportunities independently of the BCRs.

Robustness of the Results to Bias and Policy Changes

It is necessary to tightening up the ‘uncritical’ approach by introducing two specific issues of major strategic importance which affect the robustness of the results, and especially comparison of different sectors, notably:

- (a) treatment of **tax revenue**, especially from fuel taxation
- (b) implications of **road pricing**, both in its presence and its absence.

Within these two headings, there is a further consequence of other criticisms, namely concerning the **duration** of appraisal, the implications of **carbon targets**, and the implications of a requirement to make transport **improvements** (as distinct from slowing down the pace at which things get worse) as a policy aim. These are not distinguished at all in conventionally calculated BCR, but of great significance for public acceptability and political and economic strategy.

The significance of this list of complications is that they all impact differently on different types of expenditure, thus changing their relative advantage, and hence changing the picture of which changes are most beneficial. They are therefore different in nature from those

sensitivity tests which may affect all expenditures more or less equally, which are important but not treated here.

Tax Revenue

Until 2003 DfT used a classical approach to social cost benefit analysis with emphasis on the real costs of actual resources consumed, and taxes treated mainly as transfer payments where payers and receivers either balance out exactly, or nearly so if there is a cost of raising public funds. In 2003 this changed to 'NATA Appraisal' in which the indirect tax effects were included in such a way that if a road scheme induced traffic which generated more fuel tax revenue, the extra revenue was treated as a reduction of the cost of the scheme. Conversely a scheme which reduced car use, hence reduced fuel tax revenue, would produce a reduction in tax revenue treated as an extra cost of the scheme. (This adjustment was made in the case of Smarter Choices above, the extra cost being some four times larger than the average direct public money cost of interventions on average).

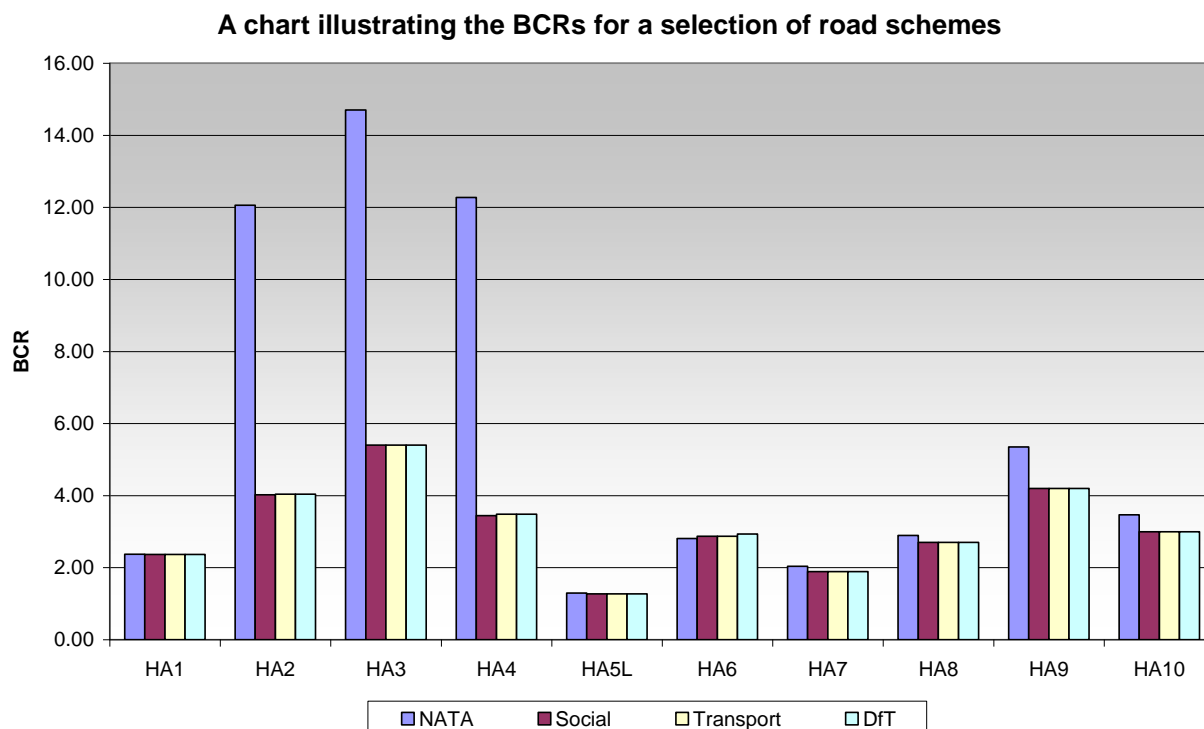
This approach was criticised because it appeared to be biased towards roads schemes and against those public transport, and also appeared to build in an incentive to public stakeholders to adopt policies which were in conflict with objectives of efficiency and environmental protection. While the net effects of any proposal on public funds will always be a policy consideration, it does not follow that including it in the benefit-cost ratio in this way is appropriate.

In 2009 DfT decided that this approach was not going to be continued, and from 2010 new schemes will be assessed using a different approach, in which tax is not directly entered into the BCR itself. (I am not certain whether this is yet being systematically applied in practice).

The problem is that nearly all the data used for this paper has been estimated using the old, criticised, and now to-be-abandoned approach. The question is, how much difference does it make? There are two published sources examining a sample of schemes under the old and new rules.

First, a study by the DfT¹⁹ reworked 10 Highways Agency schemes under several different possible methodologies is shown in Figure 17.

¹⁹ O'Sullivan P and Smith S (2009) So you thought you understood value for money? GES Conference July, DfT



The now abandoned approach is purple in the figures, labelled ‘NATA’. In 8 of the 10 cases the BCR given under the NATA approach (in purple) is higher than any other criterion, and in three of these cases the difference is very substantial indeed, a BCR of the order of 12-15 in cases where the three other methods all give BCRs of the order of 3-5. These three cases are the three whose BCR appeared to be biggest under the old criterion. In these ten cases at least, it appears that the bigger the declared BCR, the more likely it is to have been a result of using the old approach to indirect taxation.

There is at present no DfT plan to re-calculate BCRs estimated previously, though some commentators have suggested that this should be done, for schemes whose ranking may be affected by the method. This has been suggested by the second source, Buchan (2009) in particular, who carried out an analysis of a small number of specific schemes, like the DfT results above, but choosing a number of different types of schemes including some whose BCR will be better under the new approach. His results²⁰ are shown in Table 12.

²⁰ Keith Buchan, cited in Cary R, Phillips R and Harwood J (2009) The right route: improving transport decision-making, Green Alliance, November. http://www.green-alliance.org.uk/grea_p.aspx?id=4619

Table 1: Summary of comparative results under different NATA assumptions

	Benefit Cost Ratio (BCR) under original appraisal model	BCR under revised appraisal model	BCR under appraisal model with further reforms
Tram Merseytram	1.97	2.07	2.85*
Cycle Grand Union Canal Cycle Path	38.4	75.0	75.0
Road Improving the A14 between Ellington and Fen Ditton	10.83	6.69	1.3 – 3.25**
Bus Guided busway Cambridge to St Ives	4.8	6.4	7.9**
Rail Freight Expansion of rail freight (Felixstowe – Nuneaton)	5.25	10.4	10.4***

* Based on moving to a 60 year appraisal. The Merseytram case study provides several examples of how small changes in the treatment of tax revenues has a strong impact on the benefits (see the main report, *Investing in Transport: Making the Change*)

** Based on limited data

*** The carbon benefit of the rail freight scheme was already factored into the original analysis hence there is no change

While the direction and order of magnitude of change for road schemes is broadly consistent with the DfT schemes reported above, the additional information here is that for some schemes the change is in the opposite direction, notably the busway, rail freight scheme, to a lesser extent Merseytram, and very substantially for the Cycle scheme where an already very large BCR (calculated by the DfT) is made substantially greater.

This is entirely in accordance with what one would expect, so although the details of the calculations are not given in either the DfT or Buchan's results, they are both credible.

From these results, and simple considerations of logic, we can conclude that there are three main categories of scheme which will be affected, in opposite directions, by the new procedure.

First, there are 'Class A' schemes whose indirect effect is to increase tax revenue, primarily by inducing more traffic. The biggest class of such schemes are those that increase road capacity. The new rules will reduce their BCRs, compared with the 2003-2009 rules.

Secondly there are 'Class B' schemes whose indirect effect is to reduce tax revenue, primarily by reducing traffic, but potentially also by increasing fuel efficiency. This will include smarter choices, cycling and public transport improvements. The new rules will increase their BCRs compared with the 2003-2009 rules.

The third, 'Class C' is composed of measures which reduce tax revenue by increasing fuel efficiency, but at the same time the reduction in cost may induce more traffic. Some vehicle engine efficiency measures have this character. It seems likely that the reduction will be greater than the increase, but this does not have to be the case, and the effect of the new rules could in principle go either way.

Looking at the effect on the calculations in Part Two, the effects will be to reduce many of the BCRs of road schemes, by a factor which can be very large in the case of those with high apparent benefits. This would have the effect of flattening the curve for road schemes, especially at the high end. Therefore road schemes in general, especially those which induce traffic, will perform worse than the results given in Part Two, this affect possibly being

particularly strong for the ‘first tranche’ of road schemes: in other words, their robustness is particularly in question.

Conversely, the effect of the new approach will be to *increase* the BCR of those schemes whose benefits, being in part the result of less car use, have previously had the loss of fuel tax revenue counted against them. This affects schemes which reduce carbon emissions by more efficient driving, or increase physical activity, as well as those which reduce congestion by encouraging less travel or more sustainable modes. This group of schemes will perform better in future than is shown in Part Two.

It is the DfT view that the new rules do not have a great effect on project ranking, and it seems likely that this could be so particularly for choosing between schemes which are within Class A or within Class B – road schemes may be ranked more or less in the same way, and the overall list of traffic-reducing schemes may be in somewhat stable relationship to each other. (Though it is very easy to think of exceptions in both cases). But it could not possibly be the case that the ranking of traffic-increasing schemes compared with traffic-reducing schemes will be unaffected. The latter will appear better than they did, and the former worse.

It is worth saying that none of this implies that under the new procedure the indirect tax effects do not matter. They do matter, and policies have to allow for the effects. A particularly important example of this is likely to be those carbon-saving measures that result from increased engine efficiency of cars, or financial incentives to use non carbon fuels, or both. These may result in a substantial reduction in fuel tax revenue, and it will clearly be necessary to adopt tax revenue policies making up the shortfall.

Robust decisions about spending from now on require recalculating those pre-2010 appraisals (of projects not yet implemented) which were based on the old rules, for comparison with the new appraisals based on the new rules, when ‘old’ and ‘new’ projects are competing for the same funds.

The implications of road pricing

Road pricing is a method of raising net extra funds as well as delivering benefits including congestion and carbon emissions, and therefore most studies have concluded that the economic case for it is strong and robust, not depending on calculations of value for money. Since it provides both revenue and resource benefits, it performs well under both the old and new BCR calculation. This aspect is not pursued further here.

However, it is also highly relevant to the calculation of best use of *other* funds, since the changes it brings about in the pattern of demand, in turn affect the benefits of all other expenditure.

This is seen in model results from the Department for Transport annex²¹ to the Eddington Report, which I have reformatted for comparability, as shown in table 13.

²¹ Department for Transport (2006) Transport Demand to 2025 and the Economic Case for Road Pricing and Investment , DfT London December

Table 13 Marginal Benefit-Cost Ratios for Road Building With and Without Road Pricing, according to the DfT's National Transport Model

Additional Lane Kilometres	Marginal BCR without road pricing	Additional Road Kilometres	Marginal BCR with road pricing
		350-550	1.5
		550-700	1.5
		700-850	1.1
		850-1150	1.0
		1150-1500	1.1
1450-2250	3.0	1500-2450	0.9
2250-2750	2.3	2450-3700	0.7
2750-3250	1.2		
3250-3350	0.7		
3350-4450	1.0	3700-4600	0.7
4450-5200	-0.1		
5200-6150	0.2		

Note that these results are 'lumpy', ie they do not decline monotonically as is necessarily the case in the form of ordered analysis used above. DfT suggests this may be due to issues in the convergence of the model. The calculation of road capacity increases is generic, not specific schemes, eg extra lanes on whole classes of roads.

The results show that the incremental benefit of extra road construction does decline the more one builds, both with and without road pricing, as expected. But the crucial point is that while the 'without' case enables consideration of up to about 3000 or so lane kilometres before the BCR approaches 1, in the 'with' road pricing case, it is only possible to consider less than 1000. Comparing like with like, road pricing reduces the BCR of road spending substantially, eg by 70% in the roughly overlapping category 1450-2250 lane kilometres in the table (from a good BCR of 3 to an unacceptable BCR of 0.9. The reason for this is mainly that the problems of congestion which the road building had been intended to solve, are largely already solved by more rational pricing, so that the extra benefit of building the roads is small compared with their cost..

In the calculations, it was assumed that road building plans to 2015 would be unaffected by any consideration of road pricing²². A measure of the effect of road pricing is that the modelling suggested there would be an economic case for building 3250 lane kilometres by

²² This was no doubt to make the arithmetic more tractable. If there is road pricing *at any time up to about 2050*, it would probably affect the economic case for roads in the period 2006 to 2015, because with a 60 year appraisal and a high discount rate a large proportion of the estimated benefits will not occur until after 2050. That implies that some money is probably already being unnecessarily spent on projects whose costs are now and whose benefits are in the distant future, and reduced or non-existent if road pricing is implemented in the next 40 years. It would seem odd to safeguard this sort of scheme during the period 2010-2015 when considerations of public expenditure constraints are likely to remain prominent.

2025 if road pricing is not implemented, but only 700 lane kilometres if it is, a reduction in the road programme of nearly 80%, as shown in table 14 copied directly from the report.

Table 14

Table 5.1: Road build in Intervention Scenarios

England, Road Lane Km	2015	2025		
Scenario	'Baseline' Scenario	'Baseline' Scenario	Economically Justified, No Road Pricing	Economically Justified, With Road Pricing
HA Road Lane kms - additional to 2003	1,590	3,500	4,850	2,300
HA Road Lane kms - change from 2015 Baseline		1,900	3,250	700
HA Road Lane kms - change from 2025 Baseline	-	-	1,350	-1,200
Traffic (Change from 2003)	22%	31%	32%	22%
Average Delay per vehicle km (Change from 2003)	25%	30%	28%	-37%

Thus one of the indirect financial consequences of road pricing is the saving of funds on unnecessary road building. It seems to be a strong, sensible and consistent conclusion that if the future has road pricing, there is an effect on present decisions, well before such pricing would be implemented, of very substantially reducing the estimated value for money provided by expanding road capacity.

That raises two further questions: what would the effect be on public transport appraisal? And what is the implication if we can confidently assume that road pricing will *not* be implemented in the future for a period of say 30-40 years?

When road pricing is in place, at least some of the rationale for operating subsidies to public transport disappears or is reduced, namely that part justified in order to compensate for private transport charges which do not reflect the full resource costs. So this could justify reduced public expenditure on public transport. On the other hand, road pricing will result in an increased demand for public transport, and this will increase the case for expenditure on increased capacity. These conflicting considerations can be reconciled in the buoyant demand conditions of a growing market for public transport that would be an inevitable consequence of road pricing: the public transport industries themselves would have sufficient incentive to raise funds for investment and operations. The open question in that scenario is whether an expanding public transport market, with improving services, can be sufficiently attractive that it can be funded with progressively reducing costs and prices (like the expanding markets in computer technology and some food retailing, for example).

Thus the effect of road pricing is to reduce the BCRs of road projects, and to increase the BCRs of public transport projects, compared with the assumptions in part 2. It certainly reduces the value for money from road schemes, and is ambiguous about the effect on value for money from public transport schemes.

The effect of the *absence* of road pricing is, surprisingly, not a symmetrical mirror image of the effect of its presence. This is for strategic transport policy reasons resulting from the constraints on scale of possible expansion of road capacity.

This is shown also in table 14, in the last row, a measure of the severity of congestion. It is seen that with road pricing (and in this model associated with the reduced road programme) there is a significant net improvement in the level of congestion, measured as a 37% fall in the average delay: most of this effect is due to the pricing itself. However, in the *without* road pricing case, even with the much larger road construction programme that would then, under the assumptions, be warranted, congestion actually gets worse, giving an increase of 28% in average delay.

This reinforces a widely observed phenomenon, namely that most or all road proposals, appraised assuming no road pricing, provide their benefits in the form of ‘slowing down the pace at which congestion gets worse’, as measured not against an observable starting point, or any actual experience of road user, but against a 60 year forecast sometimes called the ‘do-nothing’ option. Thus the appraisal will interpret this difference between the two forecasts as a benefit, but the road user will *experience* a progressive worsening of travel conditions.

In considering the effect of this on appraisal one has to consider a sort of policy dynamic. If even the largest conceivable road programme of every road with a positive BCR is not capable of delivering improvements, the pressure will build up to ‘do something else’, and this means that in effect the case for traffic-reducing measures will become greater, not less.

Thus while it is a robust conclusion that with road pricing at some time during the 60 year appraisal lifetime of the scheme, the BCRs of road building will reduce, the reverse conclusion needs to be caveated. Without road pricing the BCRs of road schemes *as measured against a 60 year do-nothing alternative* will be higher, certainly, but the value for money of building roads *as a means of delivering detectable improvements in travelling conditions* will be lower. In that context, other means of demand management than road pricing will be the ones that get the higher value for money.

Other Caveats

For some modes it has been necessary to make assumptions about the likely distribution of BCRs around a mean, where the data base is limited, notably, for example, cycling, or is particularly difficult to interpret. Given the mean, the question arises of how sensitive the answers are to the assumptions made. A full sensitivity test is beyond the scope of this paper, but a qualitative assessment can be made as follows.

- In the limit, if all schemes in a class have the same BCR, then what was described as the ‘oversimplified’ conclusion in Part 1 does apply, and there is no need to take account of differences. There will exist neither exceptionally good examples which should be given priority, nor exceptionally bad ones which can be dropped.
- In all other cases, the higher the variance, the more very good *and* very bad schemes will exist (if the mean is robust, of course one implies the other). This means that a high variance class is more likely to have its best schemes protected against cutting, and its worse schemes dropped to make savings or better returns elsewhere.

Conclusion

Consideration of these complications reduces the reliability of the figures in Part Two, but increases the reliability of the main policy conclusions.

This apparently paradoxical result follows from observation that the main conclusion in Part Two was to give a greater priority in expenditure allocation to a particular package of policies, namely small scale improvements such as local safety measures, smarter choices, and bus and tram improvements. The two modifications in Part Three which seem likely to have the biggest effect, increase the strength of this conclusion not reduce it, as well as increasing the value for money of national rail improvements. The first tranche expenditure is seen as robust: these are even better value for money than they appeared. The case for the intelligent speed adaptation option remains more or less unchanged. The balance of the package of policies in the third tranche is shifted, with a higher emphasis on public transport and a smaller one on road construction.

Acknowledgements and Caveats

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