White Paper on

Smarter Choices

Minnerva

Networked Wisdom

Demonstrating the Impact

Summary

This White Paper describes a methodology to help make the diverse transport policies and schemes that fall under the 'Smarter Choices' banner a more central part of transport measures. Smarter Choice policies and schemes are not new; some, such as workplace and school travel plans are an established feature in many localities. Others such as car clubs and car sharing have gained some strength in specific locations across the country, but are far from widespread.

The common themes linking the varied set of Smarter Choice measures are that they are much cheaper than major transport schemes, which UK Government budget constraints have made deeply unfashionable, and that they seek to limit motorised travel, especially by low occupancy cars.

The methodology described in this paper provides an extension to traditional transport modelling, as associated with appraising transport infrastructure schemes, as these are, clearly, not designed with the characteristics of Smarter Choices in mind.

The methodology is generic and able to consider the differing Smarter Choice measures, which it does primarily by considering the extent to which travellers are willing, able, or constrained to include Smarter Choice options in their decision making. Significantly, it makes the degree of marketing of these options a material consideration. The modelling is not divorced from standard travel choice modelling and this, together with evidence that is available from experience to date with Smarter Choices, provides assurances concerning the nature of the modelling and its results.

The modelling component of the methodology is a means to a more important objective of providing well-based appraisal of Smarter Choice schemes and policies, especially when they are deployed on a wider scale than has been the experience to date. The appraisal links to standard transport appraisal methods, but is also sensitive to the wider ramifications that Smarter Choices can imply (notably relating to health outcomes). This more rigorous appraisal process than is usual with Smarter Choices provides an important basis for making soundly-based claims from the competitive pot of the Government's Local Sustainable Transport fund.

Key aspects of the methodology are provided by a framework for operating two forms of modelling in combination. The first corresponds to models compliant with the Department for Transport's WebTAG standard for variable demand modelling. Models of this form now exist for much, though not all, of the UK and some of Ireland. These models ensure that the second, Smarter Choices modelling is consistent with the broader transport context.

The Smarter Choices modelling is distinguished by the different segmentation that is used to relate travellers to the nature of Smarter Choice options. Smarter Choice interventions are often associated with 'awareness' campaigns and the modelling is able to take into account their penetration for different population segments.

1 Transport Policy on a Low Budget

1.1 The Scope for Policy

The deferring of Government policies to the imperatives of budget deficit reduction is well known and a Department for Transport (DfT) Business Plan for 2011 – 2015 has now been published[1]. In the case of transport policies, the suppression of most large transport infrastructure schemes has led to policies increasingly associated with small scale schemes; a trend that is reinforced by the concomitant Government interest in its 'Localism' agenda. The abolition of Regional Development Agencies and Regional Spatial Strategy documents has implied the removal of the regional component of transport policy. While this is potentially addressed by the nascent Local Enterprise Partnerships, the outlook for some time will remain uncertain.

Apart from a few major schemes, such as Crossrail and high speed rail (HS2), the transport policy landscape is focused on attempts to achieve worthwhile gains from low levels of expenditure.

1.2 Smarter Choices

The term 'Smarter Choices' has been used for some time to represent policies and schemes that apply a range of organisational and technical instruments to induce changes in travel behaviour that result in social and sustainable environmental benefits[2]. A primary form of such schemes is represented by Travel Plans directed at encouraging employees and parents to avoid using their cars for journeys to work and/or school, but Smarter Choices extend to city cycle schemes, travel information systems that provide details on alternative ways of making a journey, and varied other approaches. The list includes:

1) workplace travel plans
2) school travel plans
3) personalised travel planning
4) public transport information and marketing
5) real time transport information (including via mobile devices such as iPhones)
6) travel awareness campaigns
7) car clubs
8) car sharing schemes
9) cycle hire schems
10) waking and cycling schemes (infrastructure and or marketing)
11) teleworking
12) teleconferencing, and
13) home shopping.

The methodology that we describe aims to provide mechanisms capable of addressing this full range.

[1] DfT Business Plan: http://www.dft.gov.uk/about/publications/business/plan2011-15/ [Accessed 9.11.10]
[2] See for example, East Midlands Regional Assembly paper http://www.emregionalstrategy.co.uk/Smarter-Choices [Accessed 29/10/2010]

1.3 Implication for Evaluation and Appraisal

There is some evidence, and a level of vocal support, to suggest that small schemes can represent much better value options than large budget schemes, but when small schemes represent a major plank of transport policy such assessments are inevitably subject to more critical examination than has necessarily applied in the past.

To date the appraisal procedure for Smarter Choices schemes has been varied in scope and quality. In part this is because the lower budgets involved are not considered to warrant the level of scrutiny required by large transport infrastructure schemes, and partly because the evidence base for sustaining such appraisals is weak or non-existent.

It is part of the thesis of this White Paper that, if Smarter Choices are to become 'mainstream' and widespread, then their effectiveness cannot continue on the basis of hope and experiment.

This is not to imply that Smarter Choices cannot or do not generate benefits but, rather, that their potential is considerable when applied on the large scale, that is, at a much wider scale than has been the case so far. Underlying this potential is the fact that small percentage changes in travel behaviour (concerning mode choice, destination choice, and trip frequency) can result in major changes in transport system characteristics of congestion and crowding. Also recognised but not historically evaluated, are the changes in health and fitness levels arising from increases in active modes (walking and cycling)[3].

1.4 A Prize worth having

The promise of Smarter Choices to provide desirable transport outcomes for a fraction of the price of major scheme infrastructure is clearly attractive, but converting this to quantifiable planning raises challenges that this White Paper addresses.

1.5 Read on ….

Chapter 2 comments on the technical issues and challenges for evaluating Smarter Choices plans. Chapter 3 describes a new modelling methodology to address these issues. This chapter includes a degree of technical description to provide detail to the general approach that is presented. Chapter 4 discusses approaches to making the business case for Smarter Choices measures.

[3] An relevant analysis is provided by Möser, G. Bamberg, S. *The effectiveness of soft transport policy measures: A critical assessment and meta-analysis of empirical evidence* Journal of Environmental Psychology **28** (2008) 10-16.

2 Technical Issues and Challenges

2.1 Altering Travel Behaviour

The clear sub-text of much Smarter Choice planning is to limit the use of cars. For many people the car is an integral aspect of their lifestyle and their ability to undertake the functions and activities that they require. Smarter Choices therefore face strong resistance that may require measures to inhibit car use, such as workplace parking controls. However, examples also exist to demonstrate that voluntary changes in travel behaviour can also occur to a significant extent.

Car use is promoted through major marketing campaigns associated with the motor industry, and much of it is directed at lifestyle and personal identity matters. Of course, it is not just a matter of fashion and peer pressure, but also land use, social, and cultural arrangements that make car use the natural choice for most people.

Against these observations, are others arising from low levels of car ownership in some wealthy areas (usually parts of city centres) and, for some cities, higher levels of cycle usage in these same areas compared to the average.

Thus travel behaviour can be seen to be largely inflexible, but not immutable. The transitions can be quite abrupt, sometimes associated with different generations moving into an area, sometimes with a culture encouraged by certain forms of investment. Increased levels of bus usage in London, contrasting with trends elsewhere, provide an example.

Understanding the potential of Smarter Choice policies is therefore strongly linked with the motivational factors and constraints applying to individuals. This is the domain of market research, which is only weakly represented in traditional transport analysis. We address this point further in the following chapter, having first considered issues of scale.

2.2 Identifying the Differences

A traditional travel to work plan is focused on a large employer's premises or a group of employers. This means that it is possible to identify the set of individuals involved and monitor them and their travel choices specifically. This can be used to demonstrate the very local effects of a Smarter Choices policy, for example, using a web-based car sharing scheme, but the changes are too small to observe in the overall transport context, say across a city region.

However, if Smarter Choices are to be a significant transport policy instrument, then it is necessary for them to affect the transport system more demonstrably. This is essentially a matter of scale, and it is an important policy matter to understand how pervasive Smarter Choice measures need to be in order to have a clear and recognised impact on the transport system.

Using the language of telecommunications, it is necessary to be able to distinguish the signal from Smarter Choice policies from the background noise of the surrounding transport system, which can seem like an ocean in its extent compared to individual Smarter Choice schemes.

An aim of this White Paper is to indicate how evaluation of Smarter Choices can be considered alongside the operation of the wider transport system, so that their 'signal' can still be clearly discerned, and their interaction with the wider transport system understood as large scale Smarter Choice policies are considered.

3 A Modelling Methodology

3.1 Why do we need Modelling?

Following on from the previous section on the scale of interventions, we should spell out what modelling can achieve.

An important issue is induced traffic[4]. This is alluded to in Chapter 21 of *The Effects of Smarter Choice Programmes in the Sustainable Travel Towns: Full Report*[5] but the authors recognise that it has not been possible to quantify this from the Sustainable Towns surveys.

The report also mentions that the earlier 2004 Smarter Choices report considered two scenarios: a 'low intensity' and a 'high intensity' scenario. The high intensity scenario assumed that Smarter Choice measures were accompanied by policies such as reallocating road capacity and other measures to improve public transport service levels, parking control, traffic calming, pedestrianisation, cycle networks, congestion charging or other traffic restraint, other use of transport prices and fares, speed regulation, or stronger legal enforcement levels. Mixing Smarter Choices with 'hard' measures in this way adds to the complexity, and potentially raises the importance of carrying out a detailed analysis through modelling.

Important points that modelling can address are therefore:

- how much induced traffic is generated, and where? Is it likely to be significant?
- what measures could be used to lock in the benefits of Smarter Choices (reallocation of road space, traffic calming, travelling habits, etc.) and how effective would these measures be?

Looking at it from another angle, there might be corridors where it is desirable to reallocate road capacity, e.g. to enable bus priority schemes or cycle lanes. Modelling can help to determine the best households to target with Smarter Choices in order to reduce traffic levels sufficiently to allow such schemes to be implemented effectively.

Fundamentally, the role of modelling is to help in designing the best overall package of interventions, including Smarter Choices and small infrastructure schemes. The broad modelling framework that we describe below allows a wide range of impacts to be quantified, and maximises the opportunity for making strong business cases, as further discussed in Chapter 4.

Modelling also allows a large number of "what if …" tests to sift through the possible combinations. Some of this work might be done for an example town, and the results generalised to other areas. This would limit the need for an extensive set of tests in every case, although some modelling would still be useful to look at the effects of local circumstances.

Modelling can also help identify where problems are in the network, analyse the nature of the traffic contributing (local/through traffic, journey purpose, etc.). This provides information that can be used to identify candidate Smarter Choice schemes in relation to

[4] The term 'induced traffic' is open to question, but it serves as an opposite to 'suppressed traffic demand'.
[5] DfT Report March 2010 http://www.dft.gov.uk/pgr/sustainable/smarterchoices/programmes/ [Accessed 29/10/2010]

demographics, geography, and so on. This aspect can normally be addressed using existing models, which remain part of the modelling system described in this White Paper.

3.2 Segmentation

3.2.1 Some Terminology

An important basis for modelling Smarter Choices is provided by segmenting travellers into groups that are modelled differently according to the attributes of the groups. This is a standard procedure in transport models. Typically groupings include those according to the purposes for which journeys are made, and whether a car is available for a journey. These groupings are known as demand **segments**, and the classifications within these segments (journey purposes, etc) are defined through 'indices' or '**dimensions'** – here we use the latter term.

As described below, the modelling of Smarter Choices uses an additional form of segmentation that we refer to as a **behavioural category**, which reflects the **susceptibility** of a modelled traveller to include an **option** among the **set of choices** they are willing to consider. When choosing between options within a choice set, travellers will be **sensitive** to generalised cost differences between the options. This sensitivity is expressed as a mathematical **parameter** that is **calibrated** based on observed (or sometimes stated) preferences.

3.2.2 Behavioural Categories

One basis for modelling Smarter Choices according to behavioural classification is suggested in work by Jillian Anable and others[6] that, for example, identifies seven segments of:

1. Malcontented Motorists
2. Aspiring Environmentalists
3. Car Sceptics
4. Car Aspirers
5. Car Complacents
6. Reluctant Riders
7. Die Hard Drivers.

A challenge for modelling is to be able to identify data that allows populations in a study area to be segmented in this or a similar manner. In general, it will be difficult to support a level of segmentation that is as detailed as this example.

There are several sources of data available that could be useful:

- DEFRA survey of attitudes towards environmental matters [7]
- ONS Opinions Survey[8]

[6] See ANABLE J., LANE B., AND KELAY T. (2006) *A review of public attitudes to climate change and transport: summary report*. Report by The Centre for Transport Policy (Robert Gordon University), Ecolane Transport Consultancy and the Environmental Psychology Research Group (University of Surrey) for the Department for Transport, London UK. [Available at: http://www.dft.gov.uk/pgr/sustainable/areviewofpublicattitudestocl5731; Accessed: 29/10/10].

[7] DEFRA's Survey of Public Attitudes and Behaviours Toward the Environment http://www.defra.gov.uk/evidence/statistics/environment/pubatt/

[8] Omnibus Opinions Survey http://www.ons.gov.uk/about/who-we-are/our-services/omnibus-survey/index.html

- Postcode-based marketing databases such as MOSAIC and Acorn

The DEFRA survey focuses on environmental issues, and there are several questions in the survey that could be used to create attitudinal segments, including ones about switching from car to public transport, walk, or cycle. The data also implies that attitudes to environmental matters (of which transport is a part) vary by socio-economic group, most notably based on:

- age (older people are generally doing more to help the environment)

- social class/ income (higher groups generally doing more)

Some other patterns are indicated, such as Local Authority/Housing Association tenants being less receptive, though this may be correlated to household income. There are also some variations by geographical region.

Such information can enable a mapping between age/income segmentation and the attitudinal segmentation to be developed, sufficiently to allow the attitudinal segmentation to be applied to zonal data.

The DEFRA data does not allow one to distinguish between all of these groups, e.g. between Die Hard Drivers, Car Complacents and Malcontented Motorists. While it is not essential to use exactly this segmentation, it is important to pick out segments like Malcontented Motorists, who may be more open to Smarter Choices due to being fed up with congestion, rather than being particularly concerned about environmental issues in general.

The ONS Opinions Survey (formally known as the Omnibus Survey) has the potential to provide useful data. The Opinions Survey is carried out every month, though the questions are not always the same and Government departments are able to book a slot on it for their questions as the need arises. Previously questions have been asked by the DfT about experience of and attitudes to congestion, attitudes to road pricing, and attitudes to climate change and its links with transport. Some of these questions can serve to distinguish between some of the other categories. Both survey databases are accessed through the ESDS website[9].

3.3 Modelling Framework

3.3.1 An Overview

We have intimated that the nature of Smarter Choices modelling needs to be different from established forms so that the factors affecting travel choices better reflect the qualities associated with 'marketing' concerns (image, lifestyle, etc.), but this is not to imply that existing models used for understanding the transport system across large areas are redundant. Rather the modelling framework needs to reflect both forms of modelling, and its specification is largely concerned with the two forms of modelling operating in tandem.

A schematic view of the modelling framework is shown in Figure 3-1 that portrays a broad area multi-modal transport model identified as 'WebTAG VDM', that is, a variable demand model consistent with DfT WebTAG standards. In Figure 3-1 an icon of a splitting structure is used to suggest a typical hierarchic choice model.

[9] www.esds.ac.uk

It is supposed that this model segments its demand by car availability and possibly by household income category, and includes a choice model relating to trip frequency, distribution, time of day, mode, and, potentially other choices such as car park location.

The second, Smarter Choices model (SCM) also indicates a form of modelling that appears similar to the VDM choice model. However, it is additionally concerned with allocating people to behavioural categories, which is described further in Section 3.6.

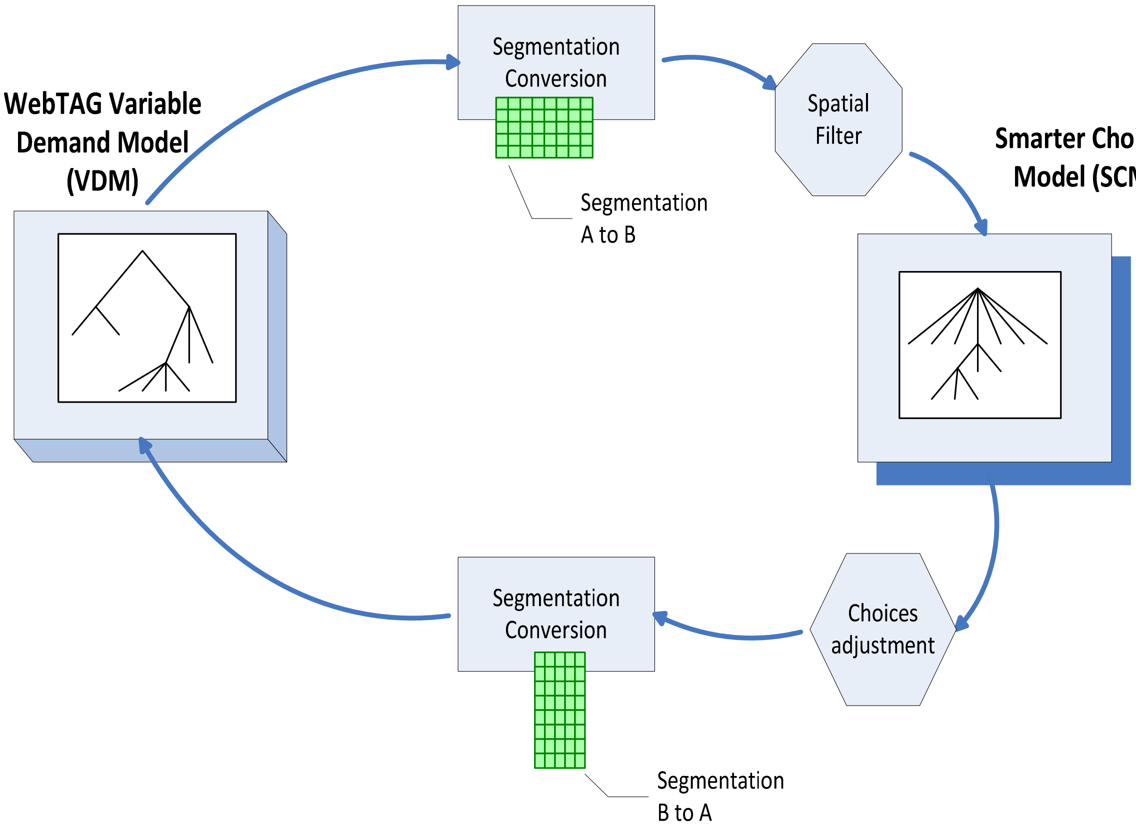

Figure 3-1 Schematic View of Modelling Framework

This modelling framework is flexible enough to deal with the varying impacts that Smarter Choices schemes might have, i.e.

- changing the *actual* or (more likely) *perceived* generalised cost of a particular transport mode (addressed via the SCM, see Section 3.3.2)
- changing the frequency of travel (VDM)
- extending the *choice set* of alternatives that people are willing to actively consider and/or their *choice sensitivity*, i.e. their readiness to consider alternatives (SCM)

The segmentation used by each of the two models is distinct, but is related through a segmentation conversion matrix that allows information to be exchanged between the two models. (In some cases a finer zoning system will be used with the SCM, so an additional conversion will map between the VDM and SCM zoning systems.)

The models may be operated independently of each other, but the most effective modelling occurs when they are used in combination, with the Smarter Choice model

(SCM) treated as a sub-model of the VDM. In this manner, the VDM is used to provide context and constraints for the SCM. Information from the VDM provides an input to the SCM and for many Smarter Choice schemes information will be filtered to restricted geographical areas of interest (corresponding to selected rows and columns of trip matrices).

The results from the SCM model may be used directly or are otherwise fed back to the VDM model in the form of choice adjustments, as described in Section 3.6.

When the number of trips involved in the SCM is small, the effect on the VDM results may be negligible, but this is less likely the more extensive the Smarter Choices scheme being assessed.

The VDM can model transport infrastructure changes that are used to help lock-in the benefits of Smarter Choice reductions in congestion, rather than simply inducing other traffic as often readily occurs.

3.3.2 Characteristics of the Two Model Types

The VDM may be characterised as providing a comprehensive model of a region. Such WebTAG-based models have become sufficiently widespread to represent a form of modelling that is broadly understood, amongst UK transport modellers, at least. Its comprehensive nature makes it impractical to pick out the detail and altered modelling views that Smarter Choices require and for which the SCM is defined.

As described above, the SCM can be used on its own (using inputs from the VDM), or its role can be selectively to alter the costs and sensitivities used in the VDM so that the VDM remains the key tool, for example, in relation to scheme and policy appraisals.

Where the SCM is derived from the VDM, it will share many VDM features, but may have more network detail in areas of relevance to Smarter Choices, such as finer zoning and inclusion of cycle and pedestrian routes. Its travel cost skim matrices will therefore be quite similar, apart from these matters of additional detail, to those of the VDM. The major difference relates to the segmentation of the population and the corresponding choice sets that are defined. For some aspects of Smarter Choices, the SCM is concerned to distinguish the perception of changes in costs from the actual changes in costs. In some cases, as discussed in the following Section 3.4, perceived costs may change considerably, but actual cost changes may be zero.

The SCM does not consider secondary changes to demands or costs as a result of Smarter Choice measures. These aspects are left to the VDM if they are of a sufficient scale to need attention, and consequently the SCM is correspondingly less encumbered. Standard VDM modelling includes provision for deriving converged solutions that balance supply and demand. It is possible to include the SCM within the balancing process, though this will only be practically necessary for large-scale schemes.

3.4 Generalised Costs

3.4.1 Adjustments to Generalised Costs

Some of the Smarter Choices policies may result in changes to the actual generalised cost of travel, for example real time travel information, which cuts the effective waiting times for public transport services. In other cases, there is no change to the actual generalised cost, but the intervention acts on people's *perception* of the cost of using alternative modes. An example of this might be a personalised travel plan, where the available bus services for a particular trip are explained in detail. While there has been no change in the characteristics of the actual bus service, in the mind of the traveller there could be a sizeable change in *perception*: where they might previously have assumed that travelling by bus would take them over an hour, say, it might in reality only take 30 minutes.

Real changes in cost may be modelled by adjusting the appropriate element of generalised cost, e.g. the wait time for public transport services. Changes in perceived cost are handled through the use of an Alternative Specific Constant (ASC), which can be adjusted to represent changes in perceived cost.

A particular difficulty is presented by the value of the ASC to be applied, as there is little direct evidence available relating to people's perceived costs, and how these change in response to Smarter Choice interventions. In the absence of more detailed data, the level of adjustment suitable for a given intervention may be set by carrying out a range of Realism Tests, where the level of cost change is calibrated to the expected outcome (in terms of modal shift), as indicated by current Smarter Choice schemes.

If the Smarter Choice policy has only been applied to a certain trip purpose or geographical area, this needs to be reflected in the adjustments made (i.e. adjustments are only made for the purpose(s) and/or zones that would be affected), noting that while the majority of the Smarter Choice policy types target the home end of the trip, and hence apply to selected production zones, school and work travel plans apply to specific attraction zones.

Changes in costs calculated by SCM can be applied to VDM once they have been transformed back to VDM dimension space. This transformation includes the weighting of costs by different behavioural groups. So if many people have believed the marketing and perceived cost have changed then the VDM costs will change also (including any changes from ASC values). This alters VDM costs on behavioural grounds (possibly as well as infrastructure grounds). Such behavioural changes would normally be accommodated through changes in sensitivities (λ values, as described in Section 3.6.2), but in this case the SCM methodology provides a basis for changing the costs.

3.4.2 Incremental Modelling and New Modes

The 'WebTAG VDM' will normally be set up as an incremental model. This means that it is not necessary to determine the absolute value of the ASCs, just the relative *changes* compared with the Base (or Reference) Year. Note that the introduction of a change in ASC will not affect the previous calibration of the VDM's demand model, as such changes in ASC are not applicable to the standard set of Realism Tests on which the calibration is based.[10]

In some cases, a Smarter Choice scheme may introduce a completely new mode. The most obvious example of this is a car-sharing scheme. Car-sharing must be considered a separate mode to private car trips due to its different characteristics: it is cheaper per person in monetary terms due to higher car occupancy, but this must be offset against the reduced convenience of having to fit in with other people's schedules. There might be additional aspects, like company car parking spaces only being made available to car sharers.

[10] WebTAG Unit 3.10.4 Variable Demand Modelling - Convergence Realism and Sensitivity

The same might be argued for cycle hire schemes, although this depends on the exact structure of the scheme. If there is effectively no 'per use' charge for the bicycle in the majority of cases, because they are generally only used for trips of less than 30 minutes, which are free, then the generalised cost would be similar to that of a private bicycle, and it might not be worthwhile to distinguish it as a separate mode.

A new mode causes difficulties in an incremental model, because there is no 'reference' cost to pivot off. This can be addressed by using the cost of a similar (but more expensive) mode as a pivot.

In other cases, Smarter Choices may effectively produce a 'new mode' for certain people, who did not include it in their choice set previously, either by physically enabling the new mode (e.g. by the introduction of a car club) or by merely marketing it effectively (e.g. travel awareness campaigns, public transport marketing). This is discussed further in Section 3.6.5 below.

3.5 Frequency Effects

Some of the Smarter Choices schemes have the potential effect of reducing trip frequency (e.g. teleworking, teleconferencing and home shopping). In broad terms this may be modelled by adjusting the VDM's trip frequency sensitivity parameter, but it is also important to recognise that background, secular changes are taking place, which are not due to the specific schemes being assessed but rather through accumulated effects of changes in information technology and, arguably, altered income levels[11].

A picture of these changes is given by Cairns et al. (2004)[12] who suggested that if an employee starts teleworking all or (more likely) some of the time, the following second-round changes in household travel patterns may result:

- The employee may make other journeys by car during the day (for example to take the children to school or to visit the shops). These journeys might have been made as part of a linked trip if she or he had been driving to work.
- Another family member may take advantage of the fact the car is available, for example to drive to work when he or she would previously have taken the bus.
- In the longer term, teleworking could encourage people to live further from their work. The benefit of reduced travel time on teleworking days would be offset (in part or even in whole) by increased travel on days when the employee travelled to work.

They go on to report that teleworkers do make some additional non-work trips, although these tend to be much shorter-distance than their previous commute, but state that there is no real evidence for the other two potential impacts.

Teleconferencing does not appear to have any significant secondary effects. Home shopping clearly generates delivery trips, and may also release the car for an alternative trip purpose, but these effects are expected to be relatively small compared to the total trips being saved (Cairns et al. (2004)).

[11] See *Travel Time Usage in the Information Age*, Centre for Transport & Society, University of West of England, http://www.transport.uwe.ac.uk/research/projects/travel-time-use/background.htm [Accessed 9/11/10]
[12] *Smarter Choices – Changing the Way We Travel*, Cairns S, Sloman L, Newson C, Anable J, Kirkbride A & Goodwin P (2004)

These changes may be addressed through the input reference (latent) demand matrices, in a similar way to the standard calculation of changes in total trip-making as a result of changes in car ownership over time. The concept of travel time budgets is applicable, so that, for example, substitution enabled by teleworking of one form of trip making (travel to work) by others (e.g. social travel) results in trip frequencies altering for more than one trip purpose group but is constrained but some form of travel time budget.

3.6 Choice Adjustment

3.6.1 Elements of the Choice Modelling

As its name implies, Smarter Choice policies are concerned with influencing the transport-relevant choices that people make. In this regard, the modelling approach we define has the primary components of:

1) Choices made to maximise personal utility
2) Allocation to sets based on the susceptibility to consider options as viable alternatives, which may be influenced by marketing
3) Reconciliation of VDM and SCM models.

The characteristics of this modelling of choice can be summarised as providing a form of choice modelling more precisely directed at Smarter Choice considerations, but which is consistent with average choice making sensitivities. Additionally and significantly, the methodology incorporates the marketing of Smarter Choices as an explicit component of policies and schemes.

The modelling of choices that maximise utility conforms to the established procedures described in WebTAG guidance, and much academic literature. For this discussion we assume that a choice model exists that provides calibrated (or adopted) sensitivity parameters by trip purpose[13] and user category[14].

People belonging to such a trip purpose and user category, say, travel to work by a high income, car-available, person category, also belong to one of the behavioural categories described in Section 3.2. The SCM modelling therefore operates in the dimension space of these behavioural categories, but is constrained by the sensitivities of the VDM dimension space.

The VDM and SCM models are both specified as incremental models that forecast from Base (or Reference) Year descriptions. Establishing Base Year descriptions is reliant on available data; this is discussed in Section 3.7 below and we consider here that the categorisation of the population by behavioural category by modelling zone is known.

3.6.2 Smarter Choice Sensitivities

The following relationship is defined that relates the choice sensitivities of the SCM to those of the VDM:

$$\lambda_u^p = \sum_1^S \psi_s^{pu} \rho_s^{ui} \phi_s^i \qquad \text{Eqn 3.1}$$

Where,

[13] For example, home-based (HB) work, HB shopping, HB education, HB other, Non-home based (NHB) employers' business, etc.
[14] For example, household car availability levels of Full, Partial, None, etc.; also, household income level.

λ_u^p VDM choice sensitivity for trip purpose, p, and user category, u. This is assumed known and previously calibrated for the study area. It may subsequently be modified by the SCM results.

ψ_s^{pu} Choice sensitivities by SCM set of segmentation dimensions, $s \in S$, and VDM segmentation dimensions, p and u. This is the choice parameter to be calibrated for the SCM.

ρ_s^{ui} Proportion of population in zone i for SCM dimension s and VDM dimension u. This is a data item.

ϕ_s^i Social and cultural factor associated with set s in zone i, within region R, $i \in R$. This factor is normally 1.0, but may be varied to import choice sensitivities from other study areas where different social and cultural values are observed to apply (e.g. propensity to cycle).

Equation 3.1 relates the SCM choice sensitivity parameters, ψ_s^{pu}, to the corresponding VDM sensitivity parameters, λ_u^p, weighted by the proportions of the population in the corresponding categories p and u for zone i, ρ_s^{ui}. Initially we assume ϕ_s^i to be 1.0, but this acts as a weighting factor as well.

Hence the problem is to estimate the set of ψ_s^{pu} sensitivities so that they are consistent with the constraint given by the value of λ_u^p, for given p and u categories.

It may be observed here that our approach is to pre-define the sensibility categories, s, but mixed logit methods[15] could be used to establish such categories from analysis of survey data. This approach is more satisfactory when sufficient data is available, but our general assumption is that this is not usually the case.

We therefore establish values of ψ_s^{pu} sensitivities by converting Equation 3.1 into the form of an objective function, G:

$$G = \lambda_u^p - \sum_1^S \psi_s^{pu} \rho_s^{ui} \phi_s^i \qquad \text{Eqn 3.2}$$

and use an optimisation procedure to find values of ψ_s^{pu} that make G = 0.

From the definitions of S, based as they are on the susceptibility to consider options, we are able to provide somewhat precise assessments of the relative levels of individual ψ_s^{pu} values. These are expressed as the upper and lower bounds for each ψ_s^{pu} value, which fit naturally into an optimisation solution framework, such as LP Simplex.

3.6.3 Population Allocations

Equations 3.1 and 3.2 treat the proportions of the zonal populations for different user and behaviour segments, ρ_s^{ui}, as input data, but in practical applications these values will require some estimation, as we now discuss.

It is presumed that we are able to establish proportions by user segment, u, as provided by a VDM model, or otherwise determined from survey data, including Census information.

[15] See Mixed Logit Modelling, WebTAG Unit 3.11.5. A literature review of Smarter Choice Modelling by Imperial College London for the Department of Transport (2008), identifies several approaches for choice set generation from data.

Information on behavioural segments, s, is also available from market research data sources such as MOSAIC, or derived from other sources such as ONS Opinions (Omnibus) surveys.

The requirement of the SCM modelling is to combine these two forms of segmentation.

It may be noted that the proportions are calculated for each of the modelling zones, i, with due allowance made for cases where SCM modelling uses finer zones than for VDM, but we largely treat this as an implementation rather than a methodological matter being discussed here.

Combining the two forms of segmentation may be approached in a number of ways. The simplest is to use a proportional allocation method[16], either bi-proportional or tri-proportional if zonal or regional constraints are applied as well. That is, vectors of user, $\mathbf{u}$, and behavioural, $\mathbf{s}$, proportions are used as row and column constraints to estimate cells of a matrix or cube, $\boldsymbol{\rho}$.

This procedure is straightforward and delivers self-consistent values, but where indicative allocations are available from survey data, it is more satisfactory to use this information to derive conditional probabilities. These may be established using such techniques as Bayesian Network Analysis to determine conditional probabilities, or from suitable tabulations of data (noting that data sparsity will be a typical problem). In some cases this analysis will provide suitable seed values for the cells of matrices or cubes used in the proportional allocation methods.

3.6.4 Regional Factors

It is a striking fact that some regions and countries have a much higher propensity to choose Smarter Choice options than others. Sometimes these may seem counter-intuitive, with limited effects of adverse weather, or positive effects of increased income on those choosing to cycle, for example.

These differences are reflected in the ϕ_s^i social and cultural parameters. In cases where the VDM sensitivities, λ_u^p, are known for two regions, A and B, but the SCM sensitivities, ψ_s^{pu}, have only been derived for region A, then Equation 3.1 enables values of ϕ_s^i to be estimated that match the region B VDM sensitivities.

This measure of regional disparity is useful for policy assessment, though not essential to the modelling, which can also operate with region-specific values of SCM sensitivities, ψ_s^{pu}.

3.6.5 Moving Between Segments

The discussion of the SCM methodology so far has concentrated on establishing choice sensitivity values, ψ_s^{pu}, for segmentations, s, that are more relevant to Smarter Choice options than the conventional p and u segmentations alone.

This provides increased precision to the modelling when Smarter Choice policies change the (generalised) costs of alternatives, but often an aim of Smarter Choice policies is to alter people's susceptibility to make a given choice. This may include techniques identical with those of commercial advertising that seek to cause people to make choices without necessarily any changes in costs but, rather, through altered perceptions and evaluations, as discussed earlier in Section 3.4.2.

16 That is, a 'Furness' method

The SCM method approaches this through the application of a **marketing transition matrix**. This defines the proportionate movement between susceptibility segmentations, *s*, that arise from single or grouped Smarter Choice policies and schemes.

A Numerical Example

We introduce the marketing transition matrix by means of a simple example shown in Table 3.1. This is followed by further discussion on the two components that determine the values of the matrix.

Table 3.1 shows a segmentation, *S*, with three associated segments, *s*, relating to willingness to change in respect of a Smarter Choices measure, say, car sharing. For those that will not change (segment #3), car sharing is not amongst their option set, but for others it is, but to varying degrees (segments #1 and #2).

Table 3.1 Example of Marketing Transition Matrix in Operation

Marketing Transition Matrix

S	*To s*	1	2	3
From s		Willing to change	No desire to change	Won't change
1	Willing to change	0%	0%	0%
2	No desire to change	20%	-20%	0%
3	Won't change	2%	10%	-12%

Market Research Data

s		Base Population
1	Willing to change	100
2	No desire to change	700
3	Won't change	200
		1000

Adjusted Segmentation

s		Change	Revised Population
1	Willing to change	144	244
2	No desire to change	-120	580
3	Won't change	-24	176
			1000

The top of Table 3.1 shows a marketing transition matrix with three behavioural categories defined. The matrix relates to a particular marketing campaign and set of policies that introduce or extend Smarter Choice options. 'Change' means change to these options. Hence, those people who already are willing to change to the options are unaffected by marketing. The middle section of Table 3.1 indicates that market research data shows that there are 100 people in this category. This also shows that most people, 700, express no [particular] desire to change [from present habits], but the marketing transition matrix implies that marketing effort will change the perceptions of 20% of this group so that they become willing to change.

The matrix implies that the marketing campaign has some effect on those who initially considered that they would not change. 10% become more susceptible to change and 2% are now in the willing category.

The consequences of these changes are shown at the end of Table 3.1.

These marketing changes only affect the susceptibility to make changes relating to travel; the actual choice is only made when taking into account comparative travel costs.

Components of the Matrix

The marketing transition matrix is formed of two components that respectively reflect specific actions and natural trends. The information on specific actions is a user-defined input that reflects the characteristics of the scheme or policy in question. For illustration, let's take an example of a scheme for establishing a car club, where the intention is to encourage people to reduce their car ownership and increase public transport usage, but not to leave them bereft of a reasonable option for using a car.

There will be two categories of people involved: people who can drive a car but do not own one, and those with a car who will dispose of it and join a car club. Here we focus on the latter category.

Dispensing with a car has financial incentives, but is also associated with perceptions of problems and of self-image. It is the task of marketing to address the psychological aspects and it is therefore the role of the marketing transition matrix to express how effective the marketing will be. This is a matter of experience and judgement, but this is no different from the assessments made when fixing any marketing budget.

There is now accumulated experience from a diverse set of Smarter Choice schemes[17] that suggest the range of behaviour change that might be expected. Further evidence can be provided by previous and new stated preference surveys, although these do not necessarily capture the effects of marketing campaigns.

The methodology thus requires estimates of the proportionate transition of people between behavioural segments, as influenced by marketing. This information is either provided with reference to previous experience (possibly supported by stated preference data) or by belief reflecting experience, as expressed through marketing expenditure[18].

The second, 'natural trends' component of the marketing transition matrix reflects the potentially transient nature of people's behaviour changes. This arises because initial enthusiasm wanes and because population change through migration and ageing introduce people who have not been affected by the marketing message. Any changes between behaviour segments must therefore be adjusted by a reversionary discounting factor. This factor will vary by time, but there is some evidence, see Section 4.1, to suggest that a long term average discount factor may be of the order of 60% (expressed as a reduction).

This can be improved in cases where repeated marketing is applied or where social trends lock in behaviour change. The latter case is often related to the notion of 'critical mass',

[17] See monitoring programme of Smarter Choices schemes being carried out in Scotland: http://www.scotland.gov.uk/Topics/Transport/sustainable-transport/Baseline/

[18] Marketing expenditure is only a guide when it may be considered effectively as 'spending your own money', rather than 'political posturing', 'spending end-of-year money', etc.

where sufficient members of a peer group adopt a behaviour to make it the norm for that group. Identification and achievement of this critical mass can therefore provide a basis for reducing the discount factor.

3.6.6 Feedback to Wider Transport Modelling

The combination of the sensitivity parameters and choice set allocations by the marketing transition matrix provides the basis for choice modelling of the Smarter Choice scheme or policy over the geographic area of interest.

For many applications this information will be sufficient, but where the effect is sufficiently widespread it is necessary to reflect the change at a wider scale as the interactions with the rest of the land use and transport system become significant.

The results of the SCM modelling, where behavioural change has been forecast, need to be reflected in altered sensitivities used by the broader scale (VDM) model.

Initially, as described in Section 3.6.2, the broader (VDM) sensitivities (λ_u^p) are used to set the more detailed SCM sensitivities (ψ_s^{pu}), but the results of the SCM modelling of marketing and behaviour change alter the segmentation of the population, so it is now the VDM sensitivities that must match the aggregate SCM sensitivities, for those zones where the effects of the Smarter Choices policy and schemes are relevant.

The VDM model is then run using these adjusted VDM sensitivities to determine the wider impacts and interactions within the general land use and transport system.

3.7 Data Requirements

The descriptions so far have indicated a variety of data sources and forms that are used in the modelling system. It will always be the case that more data is of benefit to the precision and robustness of the results, so we concentrate here on the minimum data requirements, in particular, the extra data that is required beyond the established transport model that we assume to be available.

The geographic scope of the additional data is determined by the nature of the Smarter Choices scheme or policy. In some cases this will be highly restricted, such as to specific employment areas, but in other cases, including those of most relevance to the approach we describe, it will be for rather wider areas, but not necessarily across an entire region.

One set of additional data is that used to segment the population by the type of behavioural categories discussed in Section 3.2. As indicated there, it is feasible to use and adapt some existing surveys. This requires analysis and processing, but is not necessarily a major cost.

Other data is required on the impact of marketing efforts. Some default indicators are provided by existing Smarter Choice schemes, and stated preference surveys apply if there is no related major marketing effort. Specific marketing campaigns will have associated penetration rates for different segments, and this data can be used, together with stated preference surveys, to provide information required by the marketing transition matrix. It will be important to consider the effects of several policies operating together, as their combined impact will be less than the sum of the individual parts (for example, targeting a personalised travel plan at somebody already involved in a workplace travel plan will have a limited additional impact).

Information on the extent to which 'critical mass' levels can be achieved to lock-in behavioural changes will be indicated by combining information on susceptibility from stated preference surveys and the effectiveness of marketing. If together these imply an adequate level of adoption, this may be used as evidence to suggest whether discount rates can be reduced (and hence Smarter Choice effects made more enduring).

It is also important to ensure that the 'baseline' used for modelling includes any Smarter Choices schemes, e.g. school and workplace travel plans, which are already in place[19].

3.8 Summary of Modelling Approach

Table 3-2 below summarises the approach available for modelling each of the Smarter Choices interventions listed in Section 1.2, though the extent to which the individual approaches are relevant will depend on the precise nature and marketing of each intervention. Thus, for example:

- **Frequency effects** are relevant to substitution of online activity for travel (though not necessarily in a straightforward manner, as discussed in Section 3.5), but may also be induced through responses to appeals for personal approaches to 'greener' lifestyles.
- **Real generalised costs change** when transport infrastructure or services are changed, but marketing and awareness campaigns can **change perceived generalised costs**.
- **New options**, whether actual or perceived, alter the choice sets, which introduce new costs and choice sensitivities for groups of travellers.
- The **choice sensitivity** parameters themselves are not altered by schemes and policies (once calibrated), but are adjusted to ensure consistency, at a suitable aggregate level, between VDM and SCM cases.

Table 3-2 Mechanisms Applied to Model Smarter Choices

Smarter Choice Type	Frequency	Generalised Cost (real or perceived)	Choice Set	Choice Sensitivity
Workplace travel plans		•	•	•
School travel plans		•	•	•
Personalised travel planning	•	•	•	•
Public transport information and marketing		•	•	•
Real time transport information		•	•	•
Travel awareness campaigns	•	•	•	•
Car clubs			•	
Car sharing schemes			•	

[19] See iTRACE Travel Plan management system for London : https://london.itrace.org.uk/Default.aspx

Cycle hire schemes			•	
Waking and cycling schemes		•	•	
Teleworking	•			
Teleconferencing	•			
Home shopping	•			

3.9 Confidence in the Results

The approach to modelling Smarter Choices that we have described promotes confidence in its results in a number of ways:

- The response to Smarter Choice policy and schemes is modelled by behavioural categories that are specifically relevant to the alternatives and constraints that apply, but a relationship is maintained with observed and established responses to more general changes in transport services and opportunities.
- The Smarter Choices modelling is applied at a relevant spatial scale, so that its results are not 'lost in a wider transport ocean', but the interactions with the wider transport system are modelled.
- Important practical effects of marketing, conspicuous by their absence from traditional transport modelling, are explicitly included. Consideration of the effectiveness of marketing may create problems as it can be a user input that is too directly influential on the outputs. There are practical ways of regulating the problem of inappropriate optimism or pessimism through considering stated preference data, and from estimates of the penetration rates of marketing campaigns for different population groups.
- Confidence will always be increased by better quality and more extensive data, but sufficient general data is available to provide a tool that allows justifiable investment decisions on larger scale Smarter Choice policies and schemes.
- Realism and sensitivity tests will demonstrate the model's response to the application of a range of policy 'levers', and will help to build confidence in the approach.

4 Making the Case

4.1 Appraisal of Smarter Choices

Bringing Smarter Choices into a modelling framework yields important advantages in terms of scheme appraisal, as it makes it easier to achieve consistency between the appraisal of Smarter Choices interventions and that of more traditional infrastructure schemes. This, in turn, will help to secure funding for Smarter Choices schemes, as their merits will be more clearly demonstrated.

The types of benefits to be expected from Smarter Choices schemes are not necessarily the same as for more traditional schemes, which tend to derive the majority of their benefits from travel time savings (including savings as a result of reduced congestion). While Smarter Choices schemes, by reducing car trips, do generate congestion benefits, they do not normally deliver travel time savings for the 'target' mode, which has not been changed physically. Changes to perceived cost, modelled by changes to the ASC, are not included in the appraisal.

However, Smarter Choices produce certain other benefits which are not routinely examined in detail in transport appraisal, most notably health benefits due to promotion of walking and cycling. If physical measures to improve the walking and/or cycling experience are included in the package then journey ambience effects could also be important. In addition, it is relevant to consider the accident (dis)benefits for walkers and cyclists, as well as doing the standard calculations based on the amount of (motorised) road traffic. For pure walking and cycling (infrastructure) schemes, the proportion of total benefits derived from physical fitness impacts could be as high as 77%, and those from journey ambience up to 24%[20]. For Smarter Choices schemes, the health impacts are likely to be lower than for dedicated walk and cycle schemes, but nevertheless very significant. In the Sustainable Travel Towns report, it is estimated that 49% of the benefits accrued from decongestion, with the remainder due to health, carbon and other impacts.[21] The appraisal of these additional elements is discussed in more detail below.

4.1.1 The Appraisal Process for Smarter Choices Schemes

Many of the required elements 'drop out' from applying standard appraisal techniques, namely preparation of the TEE[22] table using TUBA[23], and the calculation of other impacts such as noise, air quality, accidents, reliability and Wider Economic Benefits.

WebTAG Unit 3.14.1 sets out the DfT's guidelines for appraising walking and cycling schemes. It is appropriate to follow a similar approach for Smarter Choices interventions, which typically aim to promote walking and cycling, and hence generate the same types of benefits. The approach for walking and cycling schemes builds on the standard appraisal methodology but includes the following additional elements:

- monetisation of physical fitness benefits, comprising: benefits due to reduced rates of mortality through increased activity; and benefits due to reduced absenteeism from work (accruing as business benefits, rather than consumer benefits). Note that this

[20] WebTAG Unit 3.14.1 Guidance on the Appraisal of Walking and Cycling Schemes, Appendix – Case Studies
[21] The Effects of Smarter Choice Programmes in the Sustainable Travel Towns: Research Report, DfT, 2010
[22] Transport Economic Efficiency
[23] DfT Transport User Benefit Appraisal [software]

methodology is in its infancy, and the approach does not currently include the economic disbenefits of obesity or the costs of altered morbidity rates.

- monetisation of journey ambience benefits due to provision of improved facilities for walking and/or cycling (e.g. segregated routes, improved street lighting, cycle storage facilities, etc.)
- calculation of the change in the number of pedestrian/cyclist accidents as a result of increased walking and cycling

It is important to make provision for calculating these additional types of benefit in the appraisal of Smarter Choices schemes in order to ensure that, as far as possible, all relevant benefits are included. In particular, the inclusion of physical fitness benefits can be a key element in the appraisal.

Another area where the specific impacts of Smarter Choices initiatives may need to be reviewed is Accessibility. A DfT project looking at the appraisal of small schemes notes that Personalised Travel Planning schemes aim to improve accessibility, in the sense of accessibility of information about particular transport services, and makes a recommendation to "undertake an accessibility mapping exercise … to reveal which sections of the population are benefiting from the introduction of the scheme".[24] The improved accessibility may also lead to Wider Economic Benefits, although these are unlikely to be significant in the case of a Smarter Choices scheme. The general guidance with regard to Wider Economic Benefits should be followed.

The following table summarises the approach to the different elements of the appraisal:

Table 4-1 Elements of Appraisal for Smarter Choices

Appraisal Element	Approach
Noise	Standard techniques
Local Air Quality	Standard techniques
Greenhouse Gases	Standard techniques (TUBA)
Journey Ambience	(If applicable) Guidance on the Appraisal of Walking and Cycling schemes
Accidents	Standard techniques + Guidance on the Appraisal of Walking and Cycling schemes
Physical Fitness	Guidance on the Appraisal of Walking and Cycling schemes
Consumer Users (Travel Time, VOCs, User Charges)	Standard techniques (TUBA)
Business Users and Providers (Travel Time, VOCs, User Charges)	Standard techniques (TUBA)
Reliability	Standard techniques

[24] Appraisal of Small Schemes, online database: http://www.its.leeds.ac.uk/aoss/07/meth.html (part of a research project conducted by ITS Leeds and Atkins on behalf of the DfT)

Appraisal Element	Approach
Option Values	Standard techniques (not normally monetised)
Public Accounts	Standard techniques (TUBA)

When presenting the appraisal, the modified versions of the Monetised Costs and Benefits Table and TEE table, as set out in WebTAG Unit 3.14.1 would be appropriate. These are very similar to the standard versions, but the Monetised Costs and Benefits Table includes an extra line for physical fitness, and the TEE table an extra column to allow the benefits to cyclists and walkers to be separately identified.

4.1.2 Other considerations

There are some specific issues to be aware of in appraising Smarter Choices initiatives.

Firstly, the customary 60-year appraisal period seems inappropriate for Smarter Choices schemes, which often operate on a shorter-term basis. There is limited evidence available as to the longevity of their impacts but, as discussed in for the modelling discount factor in Section 3.6.5, a 'decay rate' of 40% per year after the end of the programme has been suggested[25]. It is possible either to:

1. choose an appraisal period that is more suitable for the scheme in question; or
2. use the 60-year period but assume that the benefits tail off through time, using the 40% decay rate or some other appropriate assumption.

It is possible to assume some annual 'maintenance cost' element, which would be the input required to sustain the effects of the scheme over a longer period.

Secondly, it may be useful to consider the differential impacts of Smarter Choices schemes on children compared with adults. This distinction is not normally made in transport appraisal, but the health impacts of increasing physical exercise are likely to be different for children, and, given the focus on school transport, these effects are now seen to be increasingly important.

Thirdly, it has been noted above that the methodologies for estimating some kinds of monetised costs and benefits (e.g. health benefits) are still at an early stage of development, so it may be appropriate to perform sensitivity tests to demonstrate the effect of changing key assumptions related to these calculations.

Finally, with the use of ASCs to model changes in perceived cost, a difference is introduced between the cost calculations used in the modelling and appraisal. There is always a risk that this can lead to anomalies, with benefits or disbenefits appearing in unexpected places. In this case, however, it is unlikely to cause great problems because the ASC will not affect routing of trips through the network, and elsewhere changes in cost will be limited to modest (but potentially widespread) reductions in car and bus times due to reduced congestion, and possibly some other small reductions, e.g. in public transport wait time.

[25] Smarter Choices – Changing the Way We Travel, DfT, 2004

4.1.3 Building the Business Case

Greater quantification of the benefits of Smarter Choices schemes will strengthen the case for their funding by putting them on a more equal footing with other types of schemes.

The rigour of the approach described here offers a means of developing the business case for much larger Smarter Choice schemes than has been customary so far.

The comprehensive nature of the approach potentially implies much detail in the modelling, of various types, but individual applications will tend to be much simpler as only a selection of Smarter Choice interventions will be involved in any one case.

The modelling framework enables straightforward 'what if...' modelling of Smarter Choices to determine the scale and nature of benefits that are potentially available. Further detail, consideration of different timescales (for 'locking-in' benefits, etc.), interactions with variable demand modelling concerns of congestion effects, and so on, can be introduced later as refinements as part of a final business case submission.