Department for Transport

Review of TAG Impacts through a wellbeing lens

Final Report

September 2024

Department for Transport
Great Minster House
33 Horseferry Road
London
SW1P 4DR

This publication is also available on our website at
www.gov.uk/government/organisations/department-for-transport

Any enquiries regarding this publication should be sent to us at
www.gov.uk/government/organisations/department-for-transport

Contents

Prepared with the assistance of KPMG and the Institute for Transport Studies, University of Leeds.

Glossary

AST	Appraisal Summary Table - part of TAG reporting
BCR	Benefit Cost Ratio - measure of Value for Money
BHPS	British Household Panel Survey (see Section 4)
CBA	Cost Benefit Analysis
CS	(Marshallian) Consumer Surplus
CVM	Contingent Valuation Method (see Section 3)
DfT	Department for Transport
ES	Ecosystem Services (see Section 3)
GHQ-12	General Health Questionnaire - 12 questions (see Section 5)
Green Book	HM Treasury (2022), *The Green Book: appraisal and evaluation in central government*
HMT	HM Treasury
HP	Hedonic Pricing (see Section 3)
IPA	Impact Pathway Approach (see Section 3)
LUTI	Land Use-Transport Interaction Model (see Section 7)
MAC	Marginal Abatement Cost (see Section 3)
NCA	Natural Capital Approach (see Section 3)
NPV	Net Present Value - measure of Public Value in TAG and the HM Treasury Green Book
ONS	Office for National Statistics
PT	Public transport
QALY	Quality Adjusted Life Year (see Sections 3,5)
RP	Revealed Preference (see Section 3)
SCBA	Social Cost Benefit Analysis
SCEA	Social Cost Effectiveness Analysis
SCGE	Spatial Computable General Equilibrium model (see Section 7)
SDR	Social Discount Rate
SP	Stated Preference (see Section 3)
SWB	Subjective Well-Being
TAG	Transport Analysis Guidance - the Department for Transport's modelling and appraisal guidance https://www.gov.uk/guidance/transport-analysis-guidance-tag
VPF	Value of a Prevented Fatality (see Section 3)
VTTS	Value of Travel Time Saving (see Section 5)
WITA	Wider Impacts in Transport Appraisal
WTP	Willingness to Pay

Non-Technical Summary

Advances in wellbeing science have made it possible to measure how people's subjective wellbeing (SWB) changes in response to a range of variables including: their income, employment; health; time use; commuting; social life; environment; security; and accessibility[1]. This report focuses on whether and how this type of evidence can be used to help assess the impacts of transport projects and policies.

The key findings are:

- There is a growing body of evidence linking transport to wellbeing. In order to be used in policy analysis and appraisal, evidence should meet certain standards. Ideally we would want it to demonstrate: i) causality, i.e. the variable *causes* the wellbeing change; ii) external validity, i.e. the relationship can be generalised and applied outside the research study; (iii) scope - the whole wellbeing impact is captured (and not double-counted in any way); and iv) accuracy - we want to know the level of confidence in the numbers.

- **Economy impacts and wellbeing.** There is now robust evidence on the relationship between income and wellbeing, which this report encourages the use of, when appraising the money impacts of transport on people with different incomes. The wellbeing impact of moving from unemployment to employment is also measurable. It would be useful if future research can also robustly measure the wellbeing impact of different forms of work.

- **Accessibility and inclusion.** The wellbeing impact of transport provision is materially different across people: e.g. those living in rural areas; people with no car available; older people; and people with disabilities. This report recommends increased segmentation in the analysis of transport improvements, specifically to capture and quantify these benefits to people.

- **Urban realm and place-based impacts.** These impacts are known to be important but the current DfT transport appraisal guidance (TAG) does not allow analysts to measure how large all the impacts on wellbeing are. This report highlights emerging evidence on the wellbeing impact of access to green space and green infrastructure, and of improved air quality. Also the importance of evidence gathering on the value

[1] e.g. Layard and De Neve, 2023; Frijters and Krekel, 2021; HM Treasury, 2021a

of the urban environment (e.g. in terms of noise and soundscape, reduced severance, and the historic environment). Recent research on the wellbeing impact of aircraft noise is important, although the consistency with existing evidence from other data is an issue.

- **Disruption and reliability.** There is interesting evidence on the wellbeing impact of disruption from roadworks (from the water sector), although further research would be required to provide useable evidence on the wellbeing impact of transport disruption across a range of settings. The report identifies reliability as another, related, area which could repay investigation through a wellbeing lens *and* potentially using passenger satisfaction data (alongside the overall life satisfaction data).

- **Travel time.** Finally, in many areas, existing valuation evidence is extensive and robust, for example the value of travel time changes. In these areas, wellbeing evidence offers the possibility of comparisons and further validation. An early study using happiness data has found values that seem compatible with the existing preference-based evidence on values of time. This is encouraging, although there is work to do to fully align the theory behind the different methods. There may be other opportunities for validation of evidence across other impacts.

Overall this report advocates further work to increase the applicability and the robustness of the wellbeing evidence base in transport policy. There is an extensive and robust body of preference-based values in the DfT TAG Data Book[2], and there will be an important task to integrate the new wellbeing evidence with the existing values.

[2] DfT (2024), TAG Data Book: https://www.gov.uk/government/publications/tag-data-book

Summary

Advances in wellbeing science have made it possible to measure subjective wellbeing (SWB) changes directly (e.g. Layard and De Neve, 2023*;* Frijters and Krekel, 2021). SWB data can be used to:

- monitor wellbeing in the population;
- evaluate policies; and
- derive impact estimates for potential use in appraisal - either in wellbeing units or monetary values.

This report focuses on how wellbeing-based evidence could be applied in transport appraisal. It follows a wider, cross-government study completed in 2021 (HM Treasury, 2021a,b) and reflects developments in the use of wellbeing evidence worldwide[3].

The project objectives were:

1. Identify which areas have the greatest potential for using wellbeing-based economic valuation approaches, and in which areas there may be more limitations to wellbeing approaches for transport appraisal.

2. Identify what future empirical research can be undertaken to populate these highest potential areas with appropriate parameters and effect sizes for appraisal.

3. Offer consistent guidance to analysts and scheme promoters on the use of SWB in appraisal, drawing on the best available evidence.

4. Develop a clear set of recommendations for developing TAG to accommodate wellbeing appraisal better in future.

These objectives are addressed in the report. Sections 1-4 set out various aspects of the background; Section 5 examines the current SWB evidence; Section 6 considers the strengths and weaknesses of different valuation methods; Section 7 looks at the

[3] The OECD's Knowledge Exchange Platform on Well-Being (KEP) mentions more than 20 countries working specifically on wellbeing measurement for policy purposes.

implications for modelling; Section 8 discusses additionality; and Sections 9-11 set out the conclusions.

Wellbeing and transport appraisal – background

The Department for Transport (DfT) develops and maintains guidance for use by analysts working on a range of transport interventions: the Transport Analysis Guidance (TAG), which is updated regularly and accessible online[4]. This guidance includes methods for the appraisal of proposed interventions - applicable to rail and public transport, roads, active travel and other modes.

Appraisals aim to measure the changes in welfare or wellbeing due to an intervention. (Note: the exact overlap and differences between welfare and wellbeing are considered in this report, in Sections 1 and 2). Appraisals are underpinned by the theoretical framework of welfare economics and make use of econometric research that has elicited values for a wide range of impacts. The DfT Value for Money Framework describes wellbeing as the basis of 'public value', and a TAG appraisal as the preferred way to quantify the change in public value due to an intervention (DfT, 2017).

TAG identifies 24 categories of impact which may be expected from transport interventions and provides guidance on how to assess each of them, including whether and how they can be valued and included in a welfare appraisal[5]. At present, 15 of these impact categories are regularly valued in appraisals (see Table 1 in the report).

Where values are needed for non-marketed impacts such as accident reduction or air quality improvement, these are drawn from a range of established valuation methods including stated preference (SP)/contingent valuation method (CVM) studies, revealed preference (RP) analysis, marginal abatement costs (MAC), the impact pathway approach (IPA) and ecosystem services (ES) (see Table 2 in the report).

Wellbeing evidence does already play a small but important role in transport appraisal - the relationship between income and wellbeing is used to support: (a) the social discount rate (SDR); and (ii) the Green Book distributional weights (see Section 5).

Forms of subjective wellbeing

The report describes the range of different subjective wellbeing (SWB) measures which are used in research (Section 4). Much of the evidence relates to:

- Life satisfaction (LS) measures, which are based on responses the question: "Overall, how satisfied are you with your life nowadays?", typically on an 11-point scale from 0 (worst) to 10 (best). These are useful for policy analysis and appraisal because they are evaluative (people are asked to reflect on their own life) and are not limited to momentary experiences or to particular feelings.

- Happiness measures. The ONS's standard question on happiness is: "Overall, how happy did you feel yesterday" on an 11-point scale. Happiness measures may also

[4] https://www.gov.uk/guidance/transport-analysis-guidance-tag

[5] Social Cost Benefit Analysis, in the standard terminology used across government (HM Treasury, 2022)

be momentary/instantaneous (e.g. in the Mappiness app[6]) - this can be useful to measure people's experience during a journey, for example.

Anxiety measures may also be relevant, since there is evidence that travel delays, interchange risk, security/safety risks and EV range all affect transport users' self-reported anxiety. Active travel helps to improve mental health and reduce depression. Although life satisfaction and happiness are strongly correlated, anxiety is less correlated with the other measures (see Table 4).

Domain satisfaction measures - such as job satisfaction and satisfaction with health - are also used in the research. Mediation models help to show how impacts are transmitted through domain satisfactions to overall life satisfaction (Section 5).

Study method

This study has worked through each of the 24 impacts in the TAG Appraisal Summary Table, identifying:

- existing valuation methods and evidence (see Section 3);
- subjective wellbeing (SWB)-based evidence (Section 5).

In order to compare different valuation studies, a set of criteria were established based on leading government and academic sources (including DfT, 2022 - TAG Unit E-1; WWCLEG, 2015):

(i) **causality** - the change in transport and the change in welfare are not simply associated, there is evidence that the change in transport causes a change in welfare, e.g., new rail service → quicker journey to work → measurable welfare change;

(ii) **external validity and reproducibility** - can the relationship between the impact and welfare change be generalised from a particular study to other settings? Are the results reproducible by other studies/methods? This could be pursued, by using a large enough segmented/representative sample, or through meta-analysis, for example;

(iii) **scope** - does the value match the intended scope of the TAG impact? Is the value 'holistic', including the whole impact? Is there any double-counting? Is the value biased due to hypothetical/framing/part-whole biases?;

(iv) **accuracy** - TAG includes confidence intervals or sensitivity ranges for values (e.g. +/- 25% on commute and business travel time savings) - how confident are we in the values emerging from a particular source?

This study assessed both the existing SWB evidence and the potential for gathering further SWB evidence, using judgement guided by the above criteria (Section 6).

[6] http://www.mappiness.org.uk/

Areas with the greatest potential – and limitations

The study found that there is a growing body of wellbeing-based evidence in the international literature (see Section 5). Some of this relates to impacts where there are existing values in TAG (e.g. travel time, employment, noise, and air quality) and some of it relates to impacts that are not currently valued. Consequently, there is potential for:

- further checking and validation of existing TAG values;
- further segmentation of values, and valuation of distributional impacts;
- broadening TAG to include impacts (or parts of impacts) that are not fully captured by current methods;
- checking for double-counting in a few cases where the existing methods do not entirely rule this out.

Validation. SWB evidence has the potential to provide further validation of values in TAG - although this requires articulation of the precise relationship between SWB and utility and, depending on the answer to that question, definition of what constitutes 'validation' in this context. So far, valuation of travel time savings (VTTS) using momentary happiness data is the most promising example. The study by Krekel and MacKerron (2023) produces values that are broadly comparable with those currently used in TAG and contained in the TAG Data Book (DfT, 2024). The TAG values are already based on a large body of high-quality SP and RP evidence, including meta-analysis. The SWB evidence requires some further unpacking and possibly data-gathering, to build confidence in it (see Section 5). This type of role could be played by SWB evidence across most TAG impacts[7].

Segmentation and distributional impacts. The SWB evidence has highlighted several dimensions in which values in TAG could be more segmented, including:

- by income
- by social segment (including age, gender and disabilities)
- spatially (particularly for place-based impacts and areas experiencing deprivation).

For money impacts on people such as changes in **income** (e.g. due to Wider Impacts), there is evidence that the size of the wellbeing impact decreases as the initial household income increases (Layard et al, 2008; Layard, 2009). In other words, there is diminishing marginal utility of income. The relationship between income and wellbeing has now been studied extensively and forms a large part of the foundation for the Green Book distributional weights, and also the income term in the Ramsey formula for discounting (HM Treasury, 2022).

This report has raised some concerns around differences in the income-wellbeing gradient between study types (in Section 10). However, the elasticity which underpins the

[7] The main exceptions are the impacts on Business although even here there may be externalities to individuals - e.g. the traveller's component of business time savings.

distributional weights is confidently estimated (the Green Book estimate is -1.3). This leads us to conclude that it would be useful for money impacts to be differentiated by the income level of the recipient, and this could potentially apply to changes in fares/travel costs as well as changes in income. There are implications for modelling, such as increased segmentation by person characteristics including income (although not necessarily to the full extent of agent-based modelling set out TAG Unit M5.4).

The amount of segmentation needs to be proportionate, since it adds complexity and cost to the analysis. The evidence clearly shows differing wellbeing responses by various user characteristics (e.g. by income level, and for people with disabilities, people living in rural areas, and the over 50s), so it will be important to understand this better (see p47-48). The evidence is less conclusive on trip-based segmentations potentially of interest to the Department, e.g. journey purpose.

Broadening TAG. This review has identified several ways in which the valuation of impacts in TAG could potentially be broadened.

- The following impacts are included in the TAG appraisal but are not regularly valued (in the welfare calculation). SWB appears to offer a promising valuation approach in these cases, although further research will be required:
    - Place-based impacts, including townscape/urban realm; regeneration; historic environment; biodiversity; landscape; and severance. Research into the wellbeing impact of regeneration, for example, highlights how empirical research is feasible, but also requires careful research design to produce values that are transferable (see below).
    - Security. Changes in personal security are already capable of valuation using SP/IPA-based values. SWB-based research allows these to be extended to include the fear of crime, which is a significant additional impact of crime and anti-social behaviour.
- The following impacts are regularly valued in TAG appraisals, however SWB research offers the potential to widen their scope.
    - Employment.
    - Health - QoL/morbidity impacts and wellbeing spillovers.
    - Accessibility, including social impacts of PT provision and potentially options values.
    - Construction/maintenance impacts.

Potential for empirical research

The study has identified several specific areas that appear particularly promising for empirical work, and Section 10 gives additional detail on the research activities which could be practicable in the short and long term.

Specific areas of opportunity for empirical work include:

- VTTS and multipliers – various work to corroborate/validate conventional SP values, further consideration of theory and re-allocation of time at the margin
- Accidents, AQ, noise, physical activity – potential work on health-related impacts
- Reliability – using multiple forms of data, including satisfaction, to strengthen the robustness of values and forecasts
- Disruption during construction and maintenance – scope for mixed methods approach (potentially in combination with Reliability)
- Place based impacts including Townscape and Urban Realm – for the reason that SWB data for residents potentially captures location-based changes in welfare

More generally, there is the opportunity for further empirical work to better understand variations in impacts across different travellers, journey purpose/mode combinations and locations, through:

- Segmentation and distribution – evidence of differential impacts by social groups, not limited to income but including income; this requires better understanding of the income coefficient in SWB and its reconciliation with the income coefficient from WTP.

Recommendations for DfT

R1: DfT should continue to invest in the development of SWB methods, with a view to their adoption in targeted areas of TAG where they bring new insights, and the requisite levels of assurance are demonstrably met.

R2: A programme of development work should be commissioned around the specific areas of a) validation; b) segmentation and distributional impacts; c) broadening of TAG values and d) double-counting, to explore practicalities and build assurance.

R3: Areas a), b) and d) would be best developed through conceptual and case study work based on impacts which are well established within TAG - a good candidate would be VTTS, possibly extending to also cover reliability and congestion.

R4: Area c) would be best developed through cross-departmental or cross-agency partnership, possibly involving HMT.

R5: As an input to R4, DfT should review the areas of opportunity identified in Section 10 of this report and determine their priorities from the perspectives of both policy and analysis.

R6: DfT should undertake a small piece of work to document outstanding technical challenges in relation to SWB and formulate an action plan towards their resolution, where appropriate working in partnership with other relevant departments and agencies.

Recommendations for analysts and scheme promoters

R7: In advance of the development work recommended in R2, there are opportunities for the implementation of SWB in business case work, but this should be limited to the following areas:

a) validation of impacts which are already covered in TAG;

b) sensitivity testing of impacts which are already covered in TAG;

c) distributional and/or segmentation analysis;

d) quantification and/or articulation of impacts which inform the narrative of the strategic case - even if such impacts are not (presently) admissible to the economic case.

1. Introduction

An important advance in wellbeing science over the past 20 years has been the ability to measure subjective wellbeing (SWB) changes directly and consistently, leading to a range of potential policy applications (see, for example, Frijters and Krekel, 2021; Layard and De Neve, 2023). These include the use of SWB data to:

- monitor wellbeing in the population;
- evaluate policies; and
- derive impact estimates for potential use in appraisal - either in wellbeing units or monetary values.

The use of subjective wellbeing evidence has been considered and advocated by the OECD (2013) and by national governments in New Zealand (Fujiwara, 2016), the UK (HM Treasury, 2021a,b) and the Nordic countries (Nordic Council of Ministers, 2021) among many others.[8] Determining the exact ways in which wellbeing evidence is best used is a key question, and currently the subject of work in progress in many countries.

Publication of the Green Book Supplementary Guidance on Wellbeing in July 2021 was an important step towards wider application of SWB-based methods in the UK. The work was authored by a specialist cross-government subgroup, named the Social Impacts Task Force, and took inputs from a range of a range of experts. The findings are set out in two documents:

- 'Wellbeing Guidance for Appraisal' (HM Treasury, 2021a). This gives guidance on definitions of wellbeing, roles in policy development, measurement methods, evidence on effect sizes, the relationship with economics and with social cost-benefit analysis (SCBA) and social cost-effectiveness analysis (SCEA), and with monitoring and evaluation;
- 'Discussion Paper on Monetisation of Effect Sizes' (HM Treasury, 2021b). This considers alternative approaches to the use of SWB evidence in appraisal, including: (i) approaches which shift the focus away from SCBA, for example using wellbeing

[8] The OECD's Knowledge Exchange Platform on Well-Being (KEP) mentions more than 20 countries working specifically on wellbeing measurement for policy purposes. https://www.oecd.org/en/about/programmes/kep.html

based SCEA across all decisions; (ii) approaches which focus on monetisation of wellbeing effects within an SCBA framework, and (iii) some combined approaches.

Forms of cost-effectiveness analysis are already widely used in the health sector (e.g. NICE, 2012) and in energy policy (e.g. DESNZ, 2023), and are now included in the appraisal of carbon reduction for transport projects (Carbon Summary Table, TAG Unit A3, p39 - DfT, 2024). Their strength is their focus on the efficient achievement of strategic goals and targets, while SCBA is applicable to questions such as "which of these options is a better use of scarce resources" and "to what extent does this option represent value for money"? The two forms of appraisal are complementary, as parts of the policy analyst's toolkit.

Wellbeing and transport appraisal

The Department for Transport (DfT) maintains, develops and updates its appraisal guidance in TAG - Transport Analysis Guidance.[9]

TAG appraisals are driven by the aim of measuring the change in welfare or wellbeing due to an intervention. They are underpinned by the theoretical framework of welfare economics and make use of econometric research that has elicited values of a wide range of impacts. The DfT Value for Money Framework makes it explicit that wellbeing is the basis of public value, and that a TAG appraisal is the preferred way to quantify the change in public value (DfT, 2017).

The central purpose of this study is to focus on the transport sector and specifically to establish how wellbeing-based impact estimates and valuation methods could be applied in transport appraisal. This includes potentially supplementing or addressing gaps in the valuation evidence which already exists. In the process of doing this, the work has sought to elucidate both the potential for the use of wellbeing evidence and its limitations.

The current version of TAG is taken as the baseline for all assessments in this report. TAG includes a Data Book, where evidence on impact values, other key appraisal parameters and background data is located. The November 2023 Data Book (v1.22) was the latest version available at the start of this review, replaced by the May 2024 Data Book (v1.23).

The study is structured as three work packages. In WP1, the main tasks were to:

- work systematically through each component of the TAG appraisal, recording and assessing the current approach to valuation, and considering the potential for SWB-based valuation;
- identify the areas with greatest potential for application of SWB-based methods.

The subsequent work packages developed recommendations for empirical work in areas where there is high potential for application of SWB-based methods (WP2), and recommendations on the application of SWB in TAG - both for analysts conducting appraisals and for DfT as the owner of the appraisal framework (WP3).

[9] https://www.gov.uk/guidance/transport-analysis-guidance-tag

In this report:

- Section 2 lists the TAG impacts to be reviewed;
- Section 3 describes the current valuation approaches used in TAG;
- Section 4 introduces the forms of subjective wellbeing (SWB) that might be incorporated into transport appraisal;
- Section 5 gives an overview of current SWB-based evidence on TAG impacts;
- Section 6 gives a critical assessment of current valuation approaches and SWB, focusing on their strengths, weaknesses and potential complementarity;
- Section 7 considers practical questions of applicability in transport modelling and appraisal;
- Section 8 considers the scope for additionality - comparing SWB-based evidence with existing valuation evidence;
- Section 9 considers the areas of greatest potential for the use of SWB;
- Section 10 identifies specific areas of opportunity for new empirical work on SWB;
- Section 11 issues recommendations, both for DfT and for analysts and scheme promoters.

2. TAG Impacts

Scope and breakdown of TAG impacts

DfT's TAG appraisal framework includes a wide range of potential impacts. This reflects the fact that transport is linked to many key drivers of human welfare, or wellbeing, and that the TAG appraisal is interested, in principle, in all potential welfare impacts of transport interventions.[10]

Table 1 shows that there are currently 24 rows in the TAG Appraisal Summary Table (AST). This is one of the key reporting tables from a TAG appraisal, and it includes the full range of impacts on social welfare. Some rows in the AST contain multiple components, e.g. 'Business users and transport providers' is a combination of five specific components (see row 1 in the Table). Most of the impacts are grouped into three categories - Economic, Environmental and Social impacts - plus a fourth category, Public Accounts, for impacts on the public finances.

In line with the principles of social CBA,[11] TAG takes into account the impacts on all groups in society, including consumers, producers, government and others who are indirectly impacted by the intervention - for example, residents impacted by air pollution or noise,[12] and workers or businesses in the wider economy who benefit from productivity improvements through agglomeration effects.[13] Throughout the development of TAG,[14] care has been taken to avoid double-counting within the welfare analysis - this is a risk particularly between the 'direct' benefits to users and the benefits measured in the wider economy. For example, the welfare calculation for 'Wider impacts' in row #4 only includes *additional* welfare benefits, over and above the user benefits to businesses (row #1). When considering introducing wellbeing evidence into TAG, we need to be aware of similar situations arising - e.g. driven by an overlap in scope between wellbeing measures and the existing TAG welfare measures - and deal with them appropriately.

[10] The welfare basis of TAG is discussed further in Section 6 of this report. This is located in the Economic dimension of the Business Case. TAG also covers the other dimensions of the Business Case, which include the Strategic, Financial, Commercial and Management dimensions.
[11] E.g. Sugden (1999), Nellthorp (2017)
[12] DfT (2024), TAG Unit A3
[13] DfT (2024), TAG Unit A2.4
[14] E.g. see Mackie and Worsley (2023) on the history of transport appraisal.

#		Impact	Components	Values in TAG	Valued in TAG - no std.	Other Values	Not valued	TAG source / alternative sources
1	Economy	Business users & transport providers	User benefits: travel time	■				TAG Data Book Table A1.3.1
			User benefits: vehicle operating costs	■				TAG Data Book Tables A1.3.7-15
			User benefits: user charges		■			No standard values
			During construction and maintenance		■			No standard values
			Providers: costs/revenues		■			No standard values
2		Reliability impact on Business users		■				TAG Unit A1.3 (Section 6 + Appendix C)
3		Regeneration			■			Linked to Place-Based Analysis and Wider Impacts.
4		Wider Impacts			■			Wider Impacts Dataset - parameters
5	Environmental	Noise		■				TAG Data Book Table A3.1
6		Air Quality		■				TAG Data Book Table A3.2
7		Greenhouse gases		■				TAG Data Book Table A3.3
8		Landscape				■		DfT (2021) VfM Framework Supplementary Guidance on Landscape
9		Townscape				■		Atkins & ITS (2011)
10		Historic Environment				■		Maddison & Mourato (1999); HE (2017)
11		Biodiversity				■		ENCA and EKN (Defra)
12		Water Environment				■		ENCA and EKN (Defra)
13	Social	Commuting and Other users	User benefits: travel time	■				TAG Data Book Table A1.3.1
			User benefits: vehicle operating costs	■				TAG Data Book Tables A1.3.7-15
			User benefits: user charges		■			No standard values
			During construction and maintenance		■			No standard values
14		Reliability impact on Commuting and Other users		■				TAG Unit A1.3 (Section 6 + Appendix C)
15		Physical activity		■				Value of a QALY - Green Book (HMT, 2022)
16		Journey quality		■				Rail: PDFH. Bus/Active Modes: TAG Data Book Tables M3.2.1. & A4.1.6//7
17		Accidents		■				TAG Data Book Tables A4.1.1-5
18		Security				■		Home Office (Heeks et al, 2018) - social costs of crime
19		Access to services					■	No standard values
20		Affordability					■	No standard values
21		Severance				■		Anciaes et al (2018)
22		Option and non-use values		■				TAG Data Book Tables A4.1.8
23	Public Accounts	Cost to Broad Transport Budget			■			Short review on wellbeing impact of taxation.
24		Indirect Tax Revenues			■			Short review on wellbeing impact of taxation.
Other parameters used in TAG:								
		Elasticity of the MU of income w.r.t. income				■		Green Book (HMT, 2022)
		Social Time Preference Rate (STPR)			■			TAG Data Book Table A1.1.1; Green Book (HMT, 2022)
		Distributional Weights				■		Green Book (HMT, 2022)

Table 1: Valuation by impact in the TAG Appraisal Summary Table

Table 1 identifies, for each TAG impact, whether valuation evidence exists that is suitable for measuring the impact on welfare/wellbeing and where that evidence is located:

- for some impacts there are standard values in TAG, usually in the TAG Data Book,[15] e.g., values per unit change in journey times, casualties, noise and carbon emissions;
- for other impacts there is an expectation that they will be valued, and methods are in place to ensure they are valued consistently in TAG,[16] however the values will be case-specific, e.g. changes in transport fares, or scheme costs;
- for some impacts valuation evidence exists in the literature, but for various reasons - e.g., issues of scope, transferability or robustness - these values have not been incorporated into TAG;
- finally, for some impacts there is a lack of valuation evidence or methodology to incorporate valuation evidence into the appraisal, e.g. access to services. There are surprisingly few impacts in this category.

[15] https://www.gov.uk/government/publications/tag-data-book

[16] e.g., using the correct unit of account and base year

Other appraisal parameters

There are other important cross-cutting parameters used in UK appraisals which rely on valuation evidence. These include particularly the social discount rate (SDR), which is set by HM Treasury (2022) and included in the TAG Data Book for use in transport appraisal. The SDR is based on the Ramsey formula, in which the elasticity of the marginal utility of income plays a key role. This elasticity relies on SWB evidence for the income-wellbeing relationship (see HM Treasury, 2022, Annex A6; Layard, Mayraz & Nickell, 2008).

The distributional weights offered in the Green Book similarly rely on the elasticity of the marginal utility of income, based on SWB evidence (HM Treasury, 2022, Annex A3). These are not straightforward to use in transport appraisal, although work has been undertaken in DfT to explore the potential for their use (Stead and Cheyney, 2023).

Distributional impacts

Distributional impacts (DIs) across groups are addressed in TAG in three ways:

- Benefits and costs are presented in the appraisal results tables, broken down by broad incidence groups including transport users (by trip purpose: business vs commuting vs other non-work purposes); transport providers (i.e. the transport industry); central and local government; and developers (for developer contributions)[17] - the positive and negative impacts on each are shown, along with the net impact;

- TAG includes a Distributional Impact Appraisal[18] which leads to reporting tables and is summarised in a column at the right of each AST, focusing on impacts by social group (including children, older people, people with a disability, Black and Minority Ethnic (BME) communities, people without access to a car and people on low incomes). The results are currently scored on a 7-point scale from Large Beneficial to Large Adverse. The method is applied to eight of the impacts in Table 1 - shown by an asterisk in the 'DI' column;

- There is also a Place-Based Analysis,[19] which looks at geographical aspects of distribution, with implications for place-based policies.

Valuation - rather than presentation/description/scoring - of distributional impacts, is currently not practised in TAG. Care is taken in the social CBA to ensure that values reflect the welfare impact and not simply 'raw' willingness-to-pay - i.e. standard or 'equity' values are used for commuting travel time by region and across income groups, and for casualties across the country and across age groups. These are common practices in appraisal internationally (Mackie and Worsley, 2013). However, the welfare consequences of distributional impacts on social groups or people with particular characteristics are not

[17] These breakdowns are shown in full in underlying tables such as the Transport Economic Efficiency (TEE) and Public Accounts (PA) tables. Summary information is carried across into the AST, e.g. the impacts on transport users versus providers, and the differentiation between business and commute/other non-work trips.

[18] DfT (2024) TAG Unit A4.2 Distributional Impact Appraisal

[19] DfT (2022) TAG Unit A4.3 Place Based Analysis

measured in value or wellbeing terms at present. As part of the review, we will explore below whether wellbeing data offers the potential to do so.

Moreover, the current equity values are not necessarily an exact measure of the wellbeing impact on individuals, since they assume the marginal wellbeing impact is constant across individuals. That, too, will be discussed in this report.

3. Current valuation approaches

Overview

The current valuation approaches used in TAG can be broadly grouped as follows.

1. Hypothetical questioning approaches broadly classified as Stated Preference (SP). SP methods include, amongst others, the Contingent Valuation Method (CVM).

2. Revealed Preference (RP) - inference of values from choice data in actual market situations.

3. Impact Pathway Approach (IPA). This includes dose-response methods widely used in health impact valuation, and is applied to noise, air quality and physical activity impacts among others in TAG. The IPA approach thus supplements valuation methods such as SP and RP to complete the valuation. For example, Years of Life Lost (YLL) due to air quality changes are valued using the standard SP-based value of a life year[20].

4. Marginal Abatement Cost (MAC), which is especially applicable to negative externalities such as carbon emissions.

5. Market prices, e.g., where markets are believed to be competitive and prices reflect public value, or where adjusted market price data can be used, e.g. vehicle operating costs;

6. Subjective Wellbeing-Based (SWB) valuation. At present, the use of this in TAG is limited to the relationship between income and wellbeing, and specifically to the income term in the social discount rate. In the wider literature there are also values for the individual wellbeing impact of employment, as distinct from unemployment. This will be covered in Chapters 4&5.

Table 2 overleaf shows the application of these approaches to different impacts in TAG. Parentheses, '()', indicate that the approach has been used in the wider literature, however the values have not been adopted in TAG Units and the TAG Data Book - usually due to transferability/applicability issues, or to lack of robustness.

[20] which is used across government (DfT, 2021a, Annex 2)

#		Impact	Components	SP, CVM	RP	IPA	MAC	Market data & models	Other, ES
1	Economy	Business users & transport providers	User benefits: travel time	•	•				
			User benefits: vehicle operating costs					•	
			User benefits: user charges					•	
			During construction and maintenance	•	•			•	
			Providers: costs/revenues					•	
2		Reliability impact on Business users		•					
3		Regeneration							
4		Wider Impacts						•	
5	Environmental	Noise				•			
6		Air Quality				•			
7		Greenhouse gases					•		
8		Landscape							(•)
9		Townscape		(•)					
10		Historic Environment		(•)					
11		Biodiversity							(•)
12		Water Environment							(•)
13	Social	Commuting and Other users	User benefits: travel time	•	•				
			User benefits: vehicle operating costs					•	
			User benefits: user charges					•	
			During construction and maintenance	•	•			•	
14		Reliability impact on Commuting and Other users		•					
15		Physical activity				•			
16		Journey quality		•					
17		Accidents		•		•			
18		Security				•			
19		Access to services							
20		Affordability							
21		Severance		(•)					
22		Option and non-use values		•					
23	Public Acc-ounts	Cost to Broad Transport Budget							
24		Indirect Tax Revenues							
Other parameters used in TAG:									
		Elasticity of the MU of income w.r.t. income							(•)
		Social Time Preference Rate (STPR)							•
		Distributional Weights							(•)
(•) in wider literature rather than TAG/TAG Data Book									

Table 2: Current valuation methods applied to TAG impacts

1. Stated Preference and hypothetical questioning methods

These methods involve hypothetical questions, in a survey or experimental setting. The two main types of SP method are the contingent valuation method (CVM) and stated choice (SC). CVM originated in the context of environmental economics where researchers were interested in monetising the environmental damages of large oil spills (Arrow et al., 1993). In CVM surveys the core question is about the respondent's willingness-to-pay (WTP) for the non-market good value of interest. For example, in the context of the value of travel time, the simplest CVM question would be to ask how much the respondent is willing to pay for a reduction of their travel time for a given mode-purpose combination from X to Y minutes. Different response formats are available for

CVM questions. Open-ended questions provide the most accurate representation of an individual's WTP, but are cognitively the most difficult to answer, especially when respondents are not overly familiar with the good being valued. To reduce the cognitive burden, researchers have used payment card methods (indicate your highest WTP from a list), bidding games (sequentially increasing or reducing the WTP bid based on Yes/No responses), referendum formats (are you willing to pay X yes/no), or double-bounded dichotomous choices formats (one additional bid after the referendum format). In selecting the response format there is a clear trade-off between the statistical precision on the WTP and the ease of response for respondents. McFadden and Train (2017) provide an extensive critique on CV methods, which largely relate to its hypothetical nature (hypothetical bias), the discrepancy between WTP and WTA estimates, insensitivities to scope and scale (what is included in the improvement and the size of the improvement respectively), and incentive compatibility (i.e. whether respondents have an incentive to express their true preferences – see also Carson and Groves (2007)). Once the WTP is elicited, CVM uses standard regression techniques appropriate for the collected data format to estimate an average WTP for the population of interest. A range of recommendations for good CVM study design exist (Johnston et al., 2017).

Whereas CVM is largely focused on aggregate WTP for a transport or environmental policy, SC methods are focused on establishing the marginal WTP for the components of the overall policy, such as improvements in travel time, reliability, crowding and costs. Still in the context of a survey, respondents are presented with a range of options, for example different route choices or modes of transport. Considering mode choice, the option to travel from A to B is then described for, e.g., car, bus and train. Each alternative is characterised by its attributes (time, reliability, crowding/congestion and travel cost). The overall disutility of travel is then assumed to be formed by these attributes, and deteriorations in each attribute are assumed to reduce overall utility. Some modes of transport will be cheaper but slower and more crowded than others. By making a choice for the most preferred option, the respondent reveals the extent to which they are willing to trade-off the different attributes against each other. Since multiple SC questions can be asked to the same respondent and the analyst can design the experiment, the limitations of mode choices in RP studies (e.g. correlation of travel time and travel costs) can be avoided and marginal WTP for reductions in travel time and other attributes can be estimated more precisely. However, many of the criticisms of CVM extend to SC methods as well, since both are operating in a hypothetical context.

2. Revealed Preference

To capture the WTP (or WTA) measure of interest, economists often study individual consumption behaviour. Ideally, individual behaviour is studied on real world markets, because in these circumstances respondents experience the real impact of spending money (or time) on goods and services in terms of their out-of-pocket expenses and personal schedule. This is in sharp contrast to eliciting individual preferences in surveys of hypothetical choices, where one does not actually have to pay for ‘chosen’ goods or services.

Revealed Preference (RP) methods represent non-market valuation studies in which individuals are studied in real-world markets where they implicitly reveal the value (or their

WTP) for the non-market good of interest. Key examples of RP methods are hedonic price and wage studies, travel-cost models, and recreational demand models (see OECD, 2018 Chapter 3 for more details on each method).

Hedonic pricing methods generally study the housing market where, using regression analysis, the price for a house is explained as a function of its attributes. For example, people are willing to pay more for a house with additional rooms, a larger garden, and with good location features. By including the non-market good of interest in the regression analysis, the impact of, for example, good access to public transport infrastructure can be studied. Nellthorp et al. (2019), as a case in point, establish the price premium on rail and road accessibility in the north of England.

In a similar vein, hedonic wage studies explain variation in wage rates by means of various characteristics: e.g. to establish the value of mortality risk reductions – also known as the value of a statistical life (VSL) or the value of a prevented fatality (VPF). Here, it is assumed that workers are willing to accept a higher exposure to mortality risks in return for a higher wage. In a recent paper, Evans and Taylor (2020) discuss best practices for hedonic wage models. A core challenge in many hedonic price and wage studies is multi-collinearity. Since many features determining housing prices (e.g., access to good schools, shops, public transport and green space) tend to be correlated with each other, it becomes hard to empirically separate one effect from another.

Travel cost and recreational demand models are more often applied in the context of environmental economics than in transport economics. Travel cost-methods establish the extent to which people are willing to travel further (in terms of monetary cost and time) to visit recreational sites of higher quality. This method is primarily focused on single-site studies and does not consider the availability of substitute sites to visit and whether people are conducting multi-purpose trips which might inflate WTP estimates. Recreational models study the choice for recreational sites (e.g. fishing trips) in the presence of available substitutes, and again explains the choice based on the quality of the site and the corresponding trade-offs with respect to access time and cost (e.g. Lupi et al., 2020).

Another example of revealed preference methods is DfT's most recent value of time study in the UK, which analysed route choices for rail journeys through the Birmingham to London corridor, where different operators offered journeys embodying different combinations of travel time and travel cost (DfT, 2015). A recent report by Dekker et al. (2018) for the DfT studies the potential for the use of RP methods in the context of value of travel time studies. Another (even more) recent report covering similar ground is Flugel et al. (2022).

3. Impact Pathway Approach

The impact pathway approach (IPA) differs slightly from the RP and SP approaches described above. Those focus mainly on the valuation of attribute changes as perceived by people (SP) or as revealed in people's market behaviour (RP). The IPA is more focused on tracing the potentially complex sequence of causal linkages from an initial policy intervention through to the final impacts on social welfare. Figure 1 describes this in the most general terms. Later we give specific, and more complex, examples.

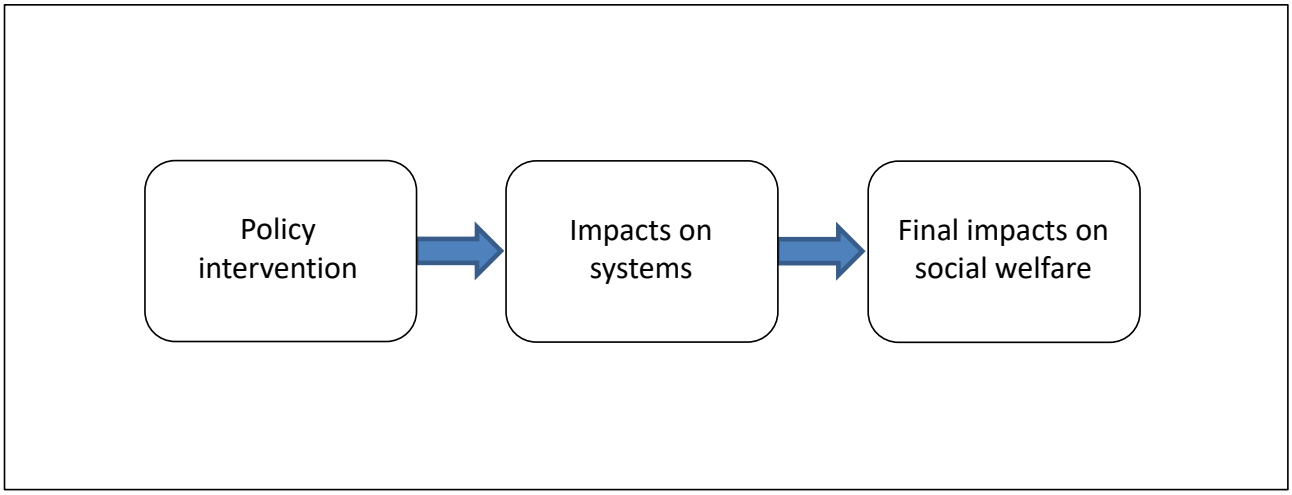

Figure 1: Impact pathway approach - overview

The systems referred to can be environmental systems, or descriptions of human health response pathways, or economic systems, or indeed multiple systems. To give a specific example, in the impact pathway for air pollution (Defra, 2023), the intermediate steps include: analysing atmospheric dispersion and concentration of pollutants; human health impact pathways using dose-response functions (e.g. various mortality and morbidity effects, and hospital admissions); ecosystem damages; damage to buildings; and productivity impacts from absenteeism/presenteeism. In each part of the impact pathway, there comes a point where valuation evidence in introduced: e.g. in the air quality example, the health impacts are valued using a value per year of life lost (YLL) which comes from a CVM study by Chilton et al (2004) and the value per quality adjusted life year (QALY) comes from stated preference research (HM Treasury, 2022, Annex A1). To some extent the 'impact pathway' is part of the forecasting model. However, as can been seen from Table 2, there are several impacts in TAG, where the 'values' embody at least some part of the potentially complex sequence of linkages between the policy intervention and the final impacts. In other words, the valuation approach can be described as 'IPA' while some components within it come from SP/CV or other valuation methods.

4. Marginal Abatement Cost

Another important method in TAG, although currently used only to value Greenhouse Gas impacts, is marginal abatement cost (MAC)[21]. In this case, the value for use in appraisal is held to be the value that - when applied throughout government decision-making - would achieve the stated policy target for carbon abatement, A*. Figure 2 shows how derivation of the MAC requires knowledge of the full range of possible interventions, their marginal abatement costs (£ per tonne of CO2 equivalent), and the amount of abatement that each would provide. The overall MAC for use in appraisal is then the marginal abatement cost at A* (DECC, 2009; BEIS, 2021).

[21] MAC was previously used for air quality in Air Quality Management Areas (AQMAs) alongside IPA-based damage costs elsewhere, however in the latest TAG update the MAC values have been removed and the IPA based values are to be used.

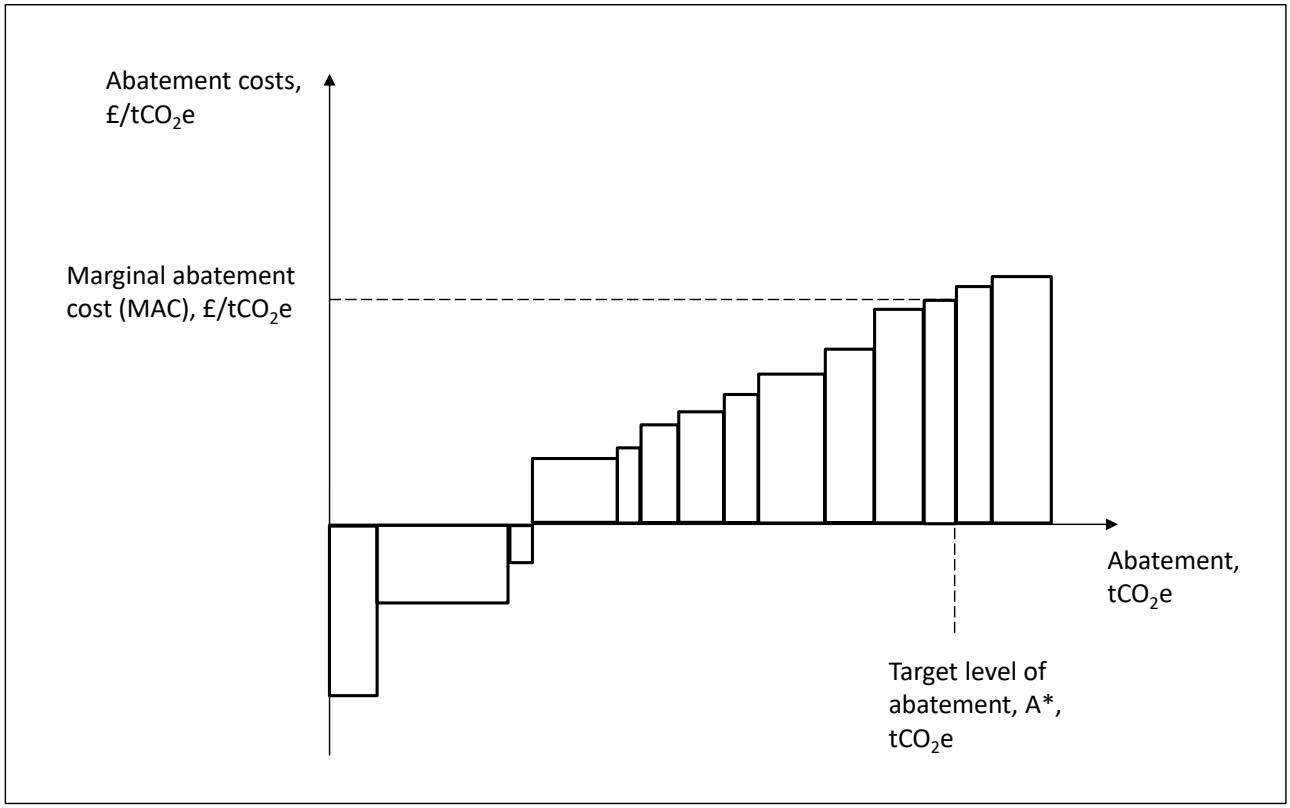

Figure 2: Derivation of the marginal abatement cost (MAC) for CO2e

Note that this makes the MAC dependent on underlying market data, for the abatement costs of the alternative interventions (the bars in Figure 2). The use of market data in TAG impact valuations is addressed in the following section.

5. Other valuation methods

Market data and models

Table 2 mentions 'market data and models' and other methods. Some impacts in TAG are more closely based on economic markets, for example the vehicle operating costs (VOCs) - including fuel and non-fuel VOCs - contain mostly items that are bought and sold in the markets for road vehicles, fuel/electricity, and other related markets. The role of TAG is to relate the market data to changes in network performance, especially distances travelled and speeds, for different vehicle types. Hence the TAG Data Book contains forecasts of: fuel and electricity prices; fuel/energy efficiency of vehicles over time; and relationships between efficiency and speed/distance. Some of this data comes from the 'emissions curves' research by Ricardo-AEA (2019) and some from DESNZ/BEIS energy projections.

Some values used in TAG appraisals will be both market-based and case-specific, e.g. rail fares within the study area, which would be analysed within "User Benefits: user charges" and within "Providers: costs/revenues". Scheme costs are also scheme specific, although cost inflation over time is covered by the Cost Inflation Series in TAG Data Book Table A1.2.1. Where values in TAG are based on market data at factor cost (e.g. VOCs, scheme

costs and the abatement costs in the carbon values) they are converted to the market prices unit of account for use in appraisal[22].

The Wider Impacts method (TAG Units A2) is supported by data in the Wider Impacts Dataset such as agglomeration elasticities and average workplace-based earnings per zone. Together these variables help to determine the monetised 'Wider Impacts' results for a project.

Natural capital and ecosystem services

Although not commonly used in transport appraisals, Biodiversity, Water Environment and Landscape impacts can be valued, making use of Natural Capital Approach (NCA) and Ecosystem Services (ES) valuation methods. These methods are summarised by the Green Book as follows:

- "Natural capital includes certain stocks of the elements of nature that have value to society, such as forests, fisheries, rivers, biodiversity, land and minerals. Natural capital includes both the living and non-living aspects of ecosystems. Stocks of natural capital provide flows of environmental or 'ecosystem' services over time. These services, often in combination with other forms of capital (human, produced and social) produce a wide range of benefits. These include use values that involve interaction with the resource, and which can have a market value (minerals, timber, freshwater) or non-market value (such as outdoor recreation, landscape amenity). They also include non-use values, such as the value people place on the existence of particular habitats or species."

These values can be seen as a special case of the impact pathway approach (IPA) with a focus on ecosystem services (see Figure 3). There are multiple steps involved between the intervention and the final impact(s) on humans, as is often the case with impact pathways across TAG.

[22] Sugden (1999); DfT (2024), TAG Unit A1.1

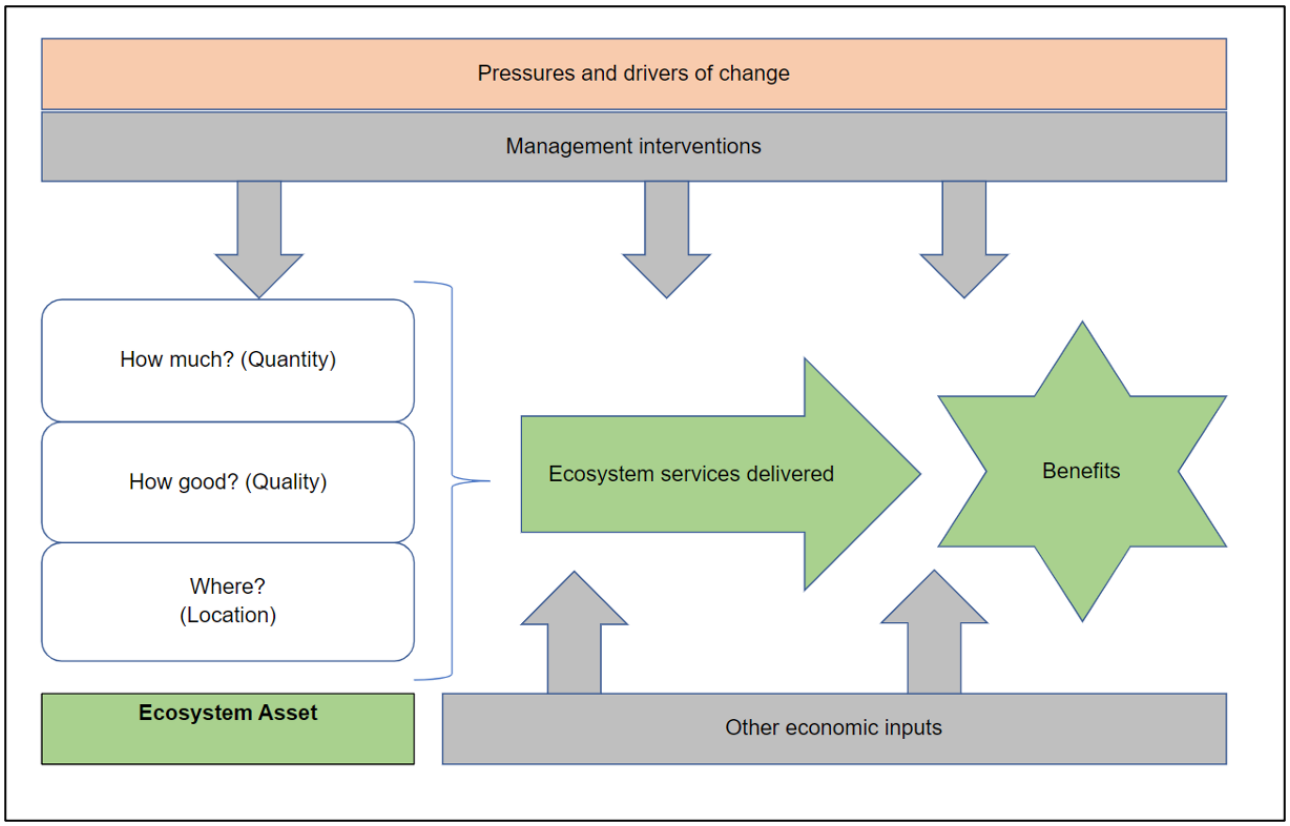

Figure 3: Natural Capital Approach involving ecosystem services impacts (Defra, 2023)

4. Forms of subjective wellbeing (SWB)

Introduction

Subjective wellbeing (SWB) data is gathered through survey questions asked to individuals about their own wellbeing - questions which are now included in national surveys in the UK and many other countries, and which may be included in more targeted surveys for particular purposes. The form of the questions has been honed over several decades (see e.g. OECD, 2013; Frijters and Krekel, 2021; Layard and De Neve, 2023). There are still new developments taking place in the form of additional questions being proposed in the UK national surveys (e.g., ONS's Review of the Measures of National Wellbeing[23]), however long-term panel datasets now exist **for four key questions** and these questions form the basis of much of the current UK evidence on wellbeing effects.

The four questions relate to different forms of subjective wellbeing. We have grouped these under three headings, in line with the Green Book Supplementary Guidance. These are significantly different in their scope - they are highly correlated, but not at 100%. It is often argued, therefore, that all of these are necessary to gain a comprehensive picture of individual wellbeing. This chapter will outline each of them in turn.

Evaluative wellbeing (life satisfaction)

Evaluative measures of wellbeing are based on questions that ask the respondent to assess or evaluate their life. In doing so, a respondent is free to take into account whatever matters to them, and the assessment is - by virtue of the way the question is framed - holistic. The timeframe is focused on the present ('nowadays' in the ONS question) but not merely a single day.

The Office for National Statistics (ONS) uses the following survey question to measure evaluative wellbeing:

- “Overall, how satisfied are you with your life nowadays?”

The response scale is an 11-point scale from 0 to 10, where 0 is “not at all” and 10 is “completely”.

[23] https://www.gov.uk/government/statistics/uk-measures-of-national-well-being-review-and-latest-insights--2

The overall evaluative nature of the question and the current but not instantaneous timeframe is appealing for the purposes of cost-benefit analysis (CBA), and many authors including the Social Impacts Task Force[24] have concluded that this is the preferred measure for appraisal purposes.

Affective wellbeing

Sometimes called experiential or hedonic wellbeing, these measures focus on feelings such as happiness or anxiety. They are sometimes described as measures of positive and negative affect.

The standard ONS survey questions to measure affective wellbeing are:

- “Overall, how happy did you feel yesterday?”
- “Overall, how anxious did you feel yesterday?”

The responses to these questions are also on the 0 to 10 scale in the ONS surveys, where 0 is “not at all” and 10 is “completely”. If the data is taken from a survey using a different scale (e.g. 1 to 7) then conversions can be made using the widely accepted formulae given in the Green Book Supplementary Guidance[25].

Eudaemonic wellbeing

Eudaemonic measures address the sense of a deeper purpose or value in life, beyond satisfaction or happiness.

The ONS survey question to measure eudaemonic wellbeing is

- “Overall, to what extent do you feel the things you do in your life are worthwhile?”

Again, the responses are on the 0 to 10 scale, where 0 is “not at all” and 10 is “completely”.

Differences between measures

Taking the 'ONS4' standard measures together, we can see the three different forms of wellbeing represented here (Table 3). We can also see the different timeframes encapsulated in the ONS questions - life satisfaction is for "your life nowadays", whereas happiness and anxiety are for "yesterday". This may be relevant to the choice of wellbeing measures in appraisal.

[24] HM Treasury (2021a) Annex 2
[25] HM Treasury (2021a) p59

Evaluative	Eudaimonic	Hedonic	
Life satisfaction	**Worthwhile**	**Happiness**	**Anxiety**
Overall, how **satisfied** are you with your life nowadays?	Overall, to what extent do you feel that the things you do in your life are **worthwhile**?	Overall, how **happy** did you feel yesterday?	On a scale where 0 is "not at all **anxious**" and 10 is "completely anxious", overall, how anxious did you feel yesterday?
0..10 scale (10=best)	0..10 (10=best)	0..10 (10=best)	0..10 (10=worst)
"Your life nowadays"	"Things you do in your life" (present)	"Yesterday"	

Table 3: Wellbeing questions, forms of wellbeing and timeframes

Other wellbeing data sources are not limited to this exact set of questions, and the timeframes vary further. For example, the Mappiness survey[26] asked respondents to report their happiness in the moment, instead of 'yesterday'. Respondents were also asked how relaxed they felt. Both of these were recorded using a smartphone app on an 11-point scale marked 'Not at all' at the left and 'Extremely' at the right.

Correlations between measures

When considering which of these four measures to use, we might ask whether they move together, and therefore whether there is potentially any advantage in looking at more than one of them. Table 4 gives results from Mukuria et al (2014) which show that life satisfaction and happiness are strongly correlated (Spearman coefficient 0.84) as are life satisfaction and worthwhile (0.8). Anxiety is only moderately correlated (-0.6 and -0.56) with life satisfaction and worthwhile, although slightly more correlated, negatively of course, with happiness (-0.67). Overall, we might use this information to justify focusing on one metric, but with a caveat that anxiety possibly requires separate attention.

	Life satisfaction	Worthwhile	Happy	Anxious (recoded)	ONS-4 total
Life satisfaction	1				
Worthwhile	0.8	1			
Happy	0.84	0.8	1		
Anxious (recoded)	0.6	0.56	0.67	1	
ONS-4 total	0.91	0.88	0.93	0.8	1

Table 4: Correlation between wellbeing measures[27]

[26] MacKerron and Mourato (2020); Krekel and MacKerron (2023)

[27] Data is from the Health improvement and Patient Outcomes (HIPO) dataset, a UK patient dataset that collected SWB and health data from patients recently discharged from hospital. Mukuria et al find similar results with other datasets.

Other related concepts and measures

The literature does contain other concepts and forms of wellbeing, aside from the personal wellbeing measures captured by the four ONS questions above. We should mention 'community wellbeing' for example, which takes a particular interest in social capital and community-level causes of wellbeing (What Works Wellbeing, 2017). Of course, community-level causal factors could also influence personal wellbeing and the effects then show up in the ONS4 or other personal wellbeing measures.

The top-level measures of personal wellbeing (above) can also be shown to relate to 'domain'-specific measures, e.g., life satisfaction is related to satisfaction with income, work and health. Meanwhile, causal determinants of changes in wellbeing have been investigated and relationships quantified for a range of determinants. We will say more on this in the next Section. Figure 4, from OECD (2013), summarises a simple model of subjective wellbeing that broadly fits the evidence outlined so far.

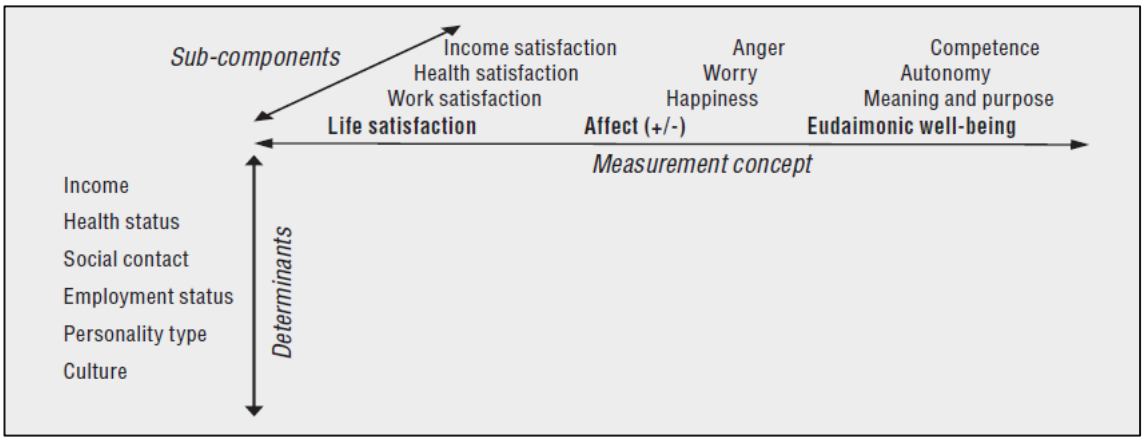

Figure 4: A simple model of subjective wellbeing (OECD, 2013)

It is also worth noting that there is a long history of wellbeing/quality of life scales being developed in the health literature, such as: the Warwick-Edinburgh Mental Wellbeing Scales (WEMWBS); the General Health Questionnaire (GHQ12); EuroQol-5D (EQ-5D); and the World Health Organisation Quality of Life instrument (WHOQOL-BREF)[28]. These are multi-criteria questionnaires, asking respondents to rate - for example: their ease of walking/mobility; their pain/discomfort; ability to perform usual activities; anxiety/depression; energy and fatigue; personal relationships; etc. The number of questions ranges from 5 in EQ-5D to 26 in WHOQOL-BREF.

Selection of a wellbeing measure

As to the selection of a measure or measures for use in policy analysis or appraisal, most authors have settled on life satisfaction as the most appealing single measure in principle[29], since it relates to an overall evaluation of the person's own life, and is not limited in time to momentary experiences, or to particular feelings (happiness/anxiety). As the Green Book Supplementary Guidance puts it:

[28] see HM Treasury (2021a) p51 for a summary.
[29] including HM Treasury (2021a) and Vander Weele et al (2020)

> Life satisfaction is ... preferred by many analysts as it incorporates positive and negative emotions (overall wellbeing being a balance of these) together with a cognitive assessment of how well one's life measures up to aspirations, goals ... which means it provides a more holistic view of wellbeing than momentary measures[30].

As Table 4 shows, however, there are reasons to think that anxiety effects may not be so well captured by the life satisfaction measure. Care should therefore be taken to consider whether the impacts of a scheme are likely to cause anxiety in particular. A brief review suggests there is evidence that transport is linked to anxiety, particularly through:

- transport noise - e.g., a systematic review and meta-analysis by Lan et al (2020) finds that exposure to transport noise is positively associated with more severe anxiety (across modes)[31];
- (un)reliability - e.g., delays and interchange risks are found to cause anxiety to rail passengers (Cheng, 2010);
- (lack of) personal security and safety - e.g. qualitative evidence indicates that in South Africa, commuters experience anxiety due to safety concerns and the experience of lateness related to public transport, and that this results in poorer work performance (Gobind, 2018);
- (lack of) physical activity - e.g. Kroesen and De Vos (2020) report evidence that active travel helps to improve mental health, and reduce depression;
- electric vehicle range anxiety - e.g. Pevec et al (2020) find that the density of the charging station network is a key factor.

Another potential caveat to the otherwise strong case for focusing on life satisfaction on the ONS 0..10 scale in policy analysis and appraisal is the issue of scale compression. Clark et al (2008) and Layard et al (2006) found that respondents using bounded scales (e.g. 0..10) tend to compress the upper end of the rating scale in their responses relative to the underlying objective data (on the determinants of wellbeing), whilst unbounded scales do not produce this effect. The magnitude of this effect was found to be small[32], but is something to bear in mind in the context of transport appraisals which cover long time periods - typically 60 years of operation for infrastructure changes[33] - and in which benefits are often forecast to grow substantially over the appraisal period. Benefits in current transport appraisal are, effectively, on an unbounded scale.

WELLBYs and welfare change

Finally, the WELLBY unit takes these timeless metrics and applies them to a given time period: one year. Specifically, the definition of a WELLBY is a one-point change in life

[30] HM Treasury (2021a), Box 5

[31] although further research is needed to establish causal links, and the quality of evidence - using the GRADE scale (https://bestpractice.bmj.com/info/toolkit/learn-ebm/what-is-grade/) is very low to low.

[32] only enough to change the elasticity of life satisfaction with respect to income from 1.3 to between 1.2 and 1.3 (Layard et al, 2006)

[33] DfT (2023) TAG Unit A1.1

satisfaction on the 0-10 scale, per person *per year* (Frijters and Krekel, 2021; HM Treasury, 2021a).

A monetary valuation of WELLBYs can be derived, either by pivoting from the value of a Quality Adjusted Life Year (QALY) or by inferring willingness-to-pay from the income-wellbeing relationship (Fujiwara and Dass, 2021). The resulting valuations are £10,000 (low estimate, using QALYs), £13,000 (central, midpoint of low and high) and £16,000 (high estimate, using the income-wellbeing relationship). These values are now part of HM Treasury guidance[34].

Thus we now have three things that can be compared: money versus wellbeing (e.g. the monetary value of a WELLBY, or people's WTP for wellbeing changes); money versus impacts (e.g. WTP values for TAG impacts); and wellbeing versus impacts (effect sizes in wellbeing units, e.g. WELLBYs, for TAG impacts).

In the next section, we go on to examine SWB evidence for specific TAG impacts.

[34] HM Treasury (2021a)

5. SWB evidence – existing and potential evidence for TAG impacts

There is SWB-based evidence in relation to a range of TAG Impacts. Most of this evidence is not suitable for immediate use, due to not being well aligned with the TAG impact definitions, not being for the UK, or not being of sufficient robustness to justify inclusion. Table 5 summarises the situation. However, the existing SWB-based income-wellbeing relationship is robust and is included in HM Treasury Green Book as well as TAG. The evidence on employment is robust and we need to consider further if/how it could be incorporated into TAG methods. There is some evidence that SWB-based values of travel time savings may provide further validation to SP & RP-based values, while environmental values based on SWB exist and discussion about their suitability for use - or further research - is needed. For most of the other impacts the focus is on *potential* evidence.

#		Impact	Components	SWB values: Relevant & Robust	SWB values: Emerging
1	Economy	Business users & transport providers	User benefits: travel time		
			User benefits: vehicle operating costs		
			User benefits: user charges		
			During construction and maintenance		
			Providers: costs/revenues		
2		Reliability impact on Business users			
3		Regeneration			
4		Wider Impacts			
5	Environmental	Noise			
6		Air Quality			
7		Greenhouse gases			
8		Landscape			
9		Townscape			
10		Historic Environment			
11		Biodiversity			
12		Water Environment			
13	Social	Commuting and Other users	User benefits: travel time		
			User benefits: vehicle operating costs		
			User benefits: user charges		
			During construction and maintenance		
14		Reliability impact on Commuting and Other users			
15		Physical activity			
16		Journey quality			
17		Accidents			
18		Security			
19		Access to services			
20		Affordability			
21		Severance			
22		Option and non-use values			
23	Public Accounts	Cost to Broad Transport Budget			
24		Indirect Tax Revenues			
Other parameters used in TAG:					
		Elasticity of the MU of income w.r.t. income			
		Social Time Preference Rate (STPR)			
		Distributional Weights			

Table 5: SWB values in the existing literature, related to TAG impacts

Income and wellbeing

The relationship between income and wellbeing is now well understood and has been robustly estimated, using SWB data from panel surveys in multiple countries (such as the British Household Panel Survey (BHPS), Understanding Society, the European Social Survey, European Quality of Life Survey, US General Social Survey, German Socio-Economic Panel Survey and World Values Survey). This relationship informs the Green Book[35] already in two key ways:

[35] HM Treasury (2022)

- it provides an important term in the Ramsey formula for the *social discount rate (SDR);* and

- it is the basis for the *distributional weights* which apply to money benefits accruing to people at different income levels.

Looking at the evidence on income and SWB is also a useful way to open up the subject of the role of SWB in appraisal.

In transport modelling, we are used to thinking about the utility of different alternatives (e.g. modes and routes), whereas in appraisal we tend to express impacts on human welfare in monetary terms - in other words we use cost-benefit analysis and we take money as the *numeraire*. From Dupuit (1844) onwards, willingness-to-pay has been used as a measure of the value of new or improved services and public goods. In modern SCBA, we take care to control for differences in ability to pay - in other words we recognise that WTP is an imperfect measure of the underlying change in utility.

Box 1: The meaning of utility

As to the meaning of utility, there is a conceptual difference between ordinal and cardinal utility[36]. *Ordinal utility* means, essentially, that people are able to rank alternatives - they can say which one they prefer (e.g. different bundles of consumer goods or different transport options). This is theoretically appealing because it requires minimal assumptions about people's underlying preferences and 'utility'. *Cardinal utility* means being able to rate utility on a scale, e.g. the 0..10 wellbeing scales discussed in Section 4. For many years, it was felt to be important to separate microeconomics and cost-benefit analysis from any underlying assumptions of cardinality or interpersonal comparability of utility. This was partially achieved: consumer theory is largely supportable by ordinal utility - recording preferences between bundles A and B rather than attempting to measure utility on a numerical scale. However, in practice discrete choice models (DCMs) are estimated using cardinal utility functions[37], and the measure of social welfare or 'public value' in appraisal is a cardinal one (Net Present Value in £). Wellbeing science takes a different direction, explicitly using self-reported wellbeing on a standardised cardinal scale to measure welfare. Some of the pioneering work focused on the relationship between income and wellbeing (e.g. Layard et al, 2008).

It should be acknowledged that there is ongoing and seemingly unresolved debate in the literature from various angles - theoretical, practical and philosophical - as to whether SWB is a replacement for or a supplement to utility (e.g. Richardson et al., 2014). This has important implications for the comparability of utility- vs. SWB-based values.

An important part of the body of work on income and wellbeing has been to establish that:

- there is econometric evidence of robust relationships between income and SWB (a cardinal measure on a 0..10 scale typically), across people;

[36] e.g. see Batley (2008); Nellthorp and Batley (2004); Sugden (2003)
[37] these differ from the wellbeing scales in that they are not standardised

- studies using panel data regressions - including the British Household Panel Survey/ Understanding Society - help to demonstrate that the relationship with SWB is not simply an association, but causal - i.e. there is measurable impact from increasing incomes;

- external validity checks have been studied, including asking third parties such as friends and family to assess the respondent's wellbeing - this evidence supports the notion that SWB is interpersonally comparable.

Many of the key findings are contained in the article by Layard et al (2008) in the Journal of Public Economics. Going further, Layard et al explored functional form and estimated the important parameter η = -1.26, the elasticity of the marginal utility of income with respect to income[38]. E.g. Table 6 shows the stability of this parameter across sub-groups and countries.

Survey dataset	η
General Social Survey	1.20 (0.91-1.48)
World Values Survey	1.25 (1.05-1.45)
European Social Survey	1.34 (1.12-1.55)
European Quality of Life Survey	1.19 (0.87-1.52)
German Socio-Economic Panel	1.26 (0.90-1.63)
British Household Panel Survey	1.30 (0.97-1.62)
Overall	1.26 (1.16-1.37)
Subgroups	
Men	1.22 (1.06-1.39)
Women	1.26 (1.11-1.40)
30-42	1.27 (1.12-1.42)
43-55	1.26 (1.10-1.41)
Low education	1.13 (0.85-1.40)
Mid education	1.21 (1.01-1.42)
High education	1.26 (1.16-1.37)
Couples	1.27 (1.11-1.43)
Never married	1.44 (1.13-1.77)
Others	1.34 (1.12-1.55)
Note: 95% confidence intervals in brackets.	

Table 6: Parameter estimates for the relationship between income and wellbeing (Layard, 2009, based on Layard et al, 2008)

This parameter, rounded to -1.3, now determines both the distributional weights[39] and the income term in the Ramsey formula for discounting[40] in the Green Book.

[38] The preferred functional form was: $w = m^{1+\eta}/1 + \eta$
[39] HM Treasury (2022) Annex A3
[40] HM Treasury (2022) Annex A6

$$\text{Distributional weight for an impact group} = \left(\frac{\text{Median income (nationally)}}{\text{Median income of impact group}}\right)^{-\eta} \quad (1)$$

$$\text{Social Discount Rate, SDR} = -\eta g + L + \delta \quad (2)$$

where g is the growth rate of consumption or real incomes, L is the catastrophic risk term and δ is the pure time preference rate. HM Treasury (2022) assumes -η=1.0 and g=2.0%. DfT (2021) noted that 1.5% is now an income growth rate in line with OBR long term forecasts, and that is compatible with an assumption -η=1.3 as suggested by the literature. Hence the overall SDR (for non-health impacts, early years) is 3.5% = 1.0*2.0% + 1.0% + 0.5% ≈ 1.3*1.5% + 1.0% + 0.5%.

Potentially, this wellbeing value of income (represented by the distributional weights) is relevant to the income impacts of transport interventions (e.g. those from a supplementary economic model or a WITA analysis[41]) and possibly to other money impacts on households - e.g. to changes in transport fares. It is also relevant to expressing the value of non-market goods in a consistent unit of account/numeraire: if studies measure a wellbeing effect in wellbeing units, then a way of converting to monetary values is needed (see 'WELLBYs and welfare change' in Section 4 above).

There is also wider evidence that we will return to later in this report, that individuals are not only affected by their own income, but by:

- the extent of income inequality;
- comparisons with others' incomes ('comparison income');
- some notion of altruism.

Such phenomena can to some extent be accommodated in standard utility-based CBA (e.g. through distributive weighting), but arguably extend to more nebulous concepts which possibly fall within the domain of behavioural economics. The latter is not however an end in itself, since it provokes additional challenges for CBA such as the ability to aggregate the derived benefits in a consistent manner within and across individuals and over time.

.

Employment and wellbeing

Another area that has emerged from three decades of empirical research showing significant and large effects on wellbeing is employment - particularly the effect of being employed compared with unemployed. Effects have been found in longitudinal studies as well as cross-sectional ones, and in general recessions versus localised employment shocks (closures) which help to demonstrate causality. The empirical evidence includes a confidence interval:

[41] TAG Units A2, M5.3

- Employment versus unemployment: wellbeing impact is 0.46 (95%CI: 0.38 to 0.53).

The underpinning evidence is methodologically strong, i.e. potential confounders are controlled for (including income), sample sizes are large, the effect is reproduced across multiple studies) and studies cover the UK (Clark et al, 2018). Therefore we can be reasonably confident that these are additional wellbeing effects from increasing (or reducing) employment versus unemployment.

Employment impacts are dealt with in the Wider Impacts units in TAG (Unit A2.3) and TAG presently includes the Tax Wedge benefit from increased employment. This is a benefit to the wider population from the extra tax revenue, but does not include the additional welfare impact on households of moving from unemployment to employment. Table 7 illustrates how this could be addressed, for a transport project which brings one additional worker into the labour market. The wellbeing impact on that worker, if they were previously unemployed, is shown in life satisfaction units first (0.46)[42] then in monetary units (£5,960 at the central estimate of the value of a WELLBY in 2021). Using the existing TAG method to calculate the tax wedge welfare gain, we find that the two are similar in size - this is a coincidence. The implication is that: including the wellbeing impact of bringing more unemployed people into employment through transport investment could roughly double the welfare benefits from the existing TAG method for labour market impacts. This only applies in the case where local labour market conditions are such that workers who would have been unemployed in 'zone *i*' are now able to access a job in 'zone *j*'.

Impact	*Wellbeing effect (LS 0..10)*	*Value, £ (2021) (using WELLBY value)*		*Tax wedge welfare gain, £ (2021)*
1 worker employed (previously unemployed)	0.46			
		Low	4,585	
		Central	5,960	5,898
		High	7,336	

Table 7: Welfare impacts of reduced unemployment using SWB, and comparison with the tax wedge benefits

WELLBYs could also be relevant for construction period jobs. Again, the method would need to reflect whether workers were being drawn from unemployment or from other jobs.

Related aspects that could be of interest include:

- The value of better quality employment, where quality is defined in terms of factors such as job security, skills, autonomy, clarity of responsibilities, supportive workplaces and social connections. Although there is evidence that these effects exist, the numerical values are reported with only low confidence, and causality is unclear[43].

- Changes towards part time working have also been investigated, and the sign of the wellbeing effect was found to depend on whether the respondent wanted more or

[42] HM Treasury (2021a) based on Clark et al. (2018)
[43] Clark et al. (2018); De Neve & Ward (2017)

fewer hours, which tended to go by gender, however there are concerns about causality[44].

- The move to more productive jobs is already included in the welfare appraisal in the form of a Tax Wedge impact (TAG Unit A2.3, Section 3.3), however the welfare implications of the increase in household income is not currently subject to the relationship between income and wellbeing (above). This could be explored.

Travel time and wellbeing

We have looked carefully at the emerging findings from two studies in particular:

- work by Krekel and McKerron (2023). This study uses the Mappiness dataset, which contains a happiness variable (0..100 scale) gathered using a smartphone app. The dataset is large, including 2,235,733 total observations, of which approximately 9% are during 'travelling/commuting'.

- Clark et al (2020), on the other hand, have used the Understanding Society dataset (79,793 observations from 26,551 individuals across the six waves of this household survey from 2009/10-2014/15). The authors attempted to measure the impact of commuting on life satisfaction.

A key methodological difference compared with the current SP/RP based values of travel time savings (VTTS) is that the **Krekel and McKerron (2023)** study includes no stimulus/shock to travel times, nor any choices between alternative travel options. Instead the marginal value is based on the measured utility difference between time spent travelling and time spent in a weighted average of other activities[45]. When combined with the marginal utility of income[46], this gives a monetary value of transferring time from one activity to another (from travel to weighted average of all other activities). Details can be found in the pro-forma for non-work Travel Time (in Appendix 1).

The Krekel and McKerron study does not identify transport modes, and we have recommended a mode question be added to any future data gathering. Similarly it does not identify trip stage or journey purpose, or crowding/travel conditions (and we have recommended these as other potential future questions). We also recommended re-analysing the current dataset to try to isolate in-vehicle time and walking time.

Nevertheless, the Krekel and McKerron study produces marginal values of travel time which are capable - broadly speaking - of being 'reconciled'[47] with the existing TAG values, based on SP evidence with some validation against RP (Table 8).

---

[44] Frijters and Krekel (2021), Table 2.3

[45] This appears to be the difference between the average utilities of time spent in the two activities - it may be worth investigating more deeply how this relates to the marginal utilities of time spent in activities.

[46] utility measured in happiness units - measured within the same study

[47] The notion of 'reconciliation' in this context would arguably benefit from tighter definition, depending on what perspective is adopted on the relationship between SWB and utility (see Box 1). In other words, do they give different measures of the same phenomenon, or are they measuring different phenomena? To complicate matters further, might the answer to the latter question vary by context?

All values in £/hour, 2010 prices and values, at market prices	SP+ TAG Data Book, Nov 2023	SWB (Happiness) K&M (2023)
In-vehicle time		
Business (average)	19.27	—
Commute	9.95	—
Other Non-Work	4.54	—
Weighted mean*	6.46	7.76
(*by distance, NTS0403c)		
Wait time (during travel)		
Business (average)	38.53	
Commute	19.91	
Other Non-Work	9.09	
Weighted mean*	10.56	18.14
(*by distance, NTS0403c)		
Wait time multiplier	2.0	2.3

Table 8: Comparison of Krekel and McKerron (2023) values with TAG values of travel time savings

From Table 8, firstly we note that the K&M value of £7.76/hr is not strictly an in-vehicle time (IVT) value – it includes any travel time, so includes some wait, interchange, access & egress time. This could easily explain why it lies 20% above the equivalent TAG IVT value. Secondly we note that the wait time value in K&M (2023) is considerably higher than the distance-weighted mean TAG value, however it is conceivable that 'waiting/queuing' occurs more during Commute and Business time, than in Other Non-Work - and in the Commute context the K&M wait time value is not out of line with TAG. Finally the overall wait time multiplier in K&M (2023) is 2.3 versus 2.0 in TAG. These comparisons - a first attempt at triangulation - do not prove anything in relation to the equivalence of the valuation methods at this stage, however they offer at least a suggestion that further investigation of this is worthwhile. That is, it would be a useful step to reconcile the methods mathematically and determine the extent to which the two metrics measure the same concept, and with further data gathering and analysis using happiness data, to compare the results for comparably-defined variables, with confidence intervals.

The **Clark et al (2020) results** are different: instead of momentary happiness, they seek to relate commute time to life satisfaction. The findings, summarised below, are multi-faceted and raise further questions.

- The study finds highly significant negative relationships between commute time and two 'domain satisfactions': (i) job satisfaction; and (ii) satisfaction with the amount of leisure time (Table 9). These are based on 'within-individual' changes in commute time over the six years of survey data - so it is possible to infer causality (the cross-sectional 'between-individuals' coefficients are also shown in the table).

Dependent variable	Independent variables		
	Domain Satisfactions	Impact of Commute Time (mins)	
		Within-individual over time	*Between individuals*
Job Satisfaction		-0.0011***	*-0.0018****
Leisure Time Satisfaction		-0.0030***	*-0.0015***
Life Satisfaction		-0.0001	*-0.0014***
Combined model: Life Satisfaction	Job Satisfaction: 0.0567*** Leisure Time Satisfaction: 0.3709***	0.0012***	*-0.0001*

Notes: ***significant with 99% confidence, **95% confidence.

Table 9: Four models linking commute time with life satisfaction and/or domain satisfactions (Clark et al., 2020)

- There is also a significant negative association between commute time and overall life satisfaction when comparing across individuals, however no significant impact from within-individual changes in commute time over time (Table 9). The reasons for these findings are carefully considered by the authors. It seems likely that individuals are balancing commute time against other factors (such as earnings, job roles and housing).

- Very few of the respondents in the dataset would have experienced an exogenous shock to their commute time - e.g. opening of a new rail station or a major scheme on their regular commute. Most of the variation in commute times will be: (i) as a consequence of adjustments in home or work location - either to improve overall wellbeing or to minimise a negative shock to wellbeing (e.g. in response to a redundancy or rent increase); or (ii) 'noise' in the data associated with year-to-year variation in commute times or individual perceptions of commute time[48].

- The authors conducted a further set of regressions, adding job satisfaction and leisure time satisfaction as additional controls (last row of Table 9). These regressions show that when leisure time satisfaction is included, commute time

[48] There was variation in the data: the mean change in commute time from wave to wave in the survey was 16 minutes (each way) for those who changed commute destination or moved home, and 6 minutes for those who did not (Clark et al, 2020, Table 5).

becomes a significant *positive* determinant of life satisfaction. This too is suggestive - that there are "unobserved compensatory factors associated with longer commutes - such as improved residential and/or employment situations which are not captured in the control variables" (Clark et al, 2020, p2798). We note that two variables which are not included in any of these models are housing costs and quality.

- For future research, it could be more efficient to focus on locations where there has been an exogenous change in commute times, or on users of improved services. Boost surveys or separate targeted surveys would be worth considering - the latter would ideally be designed so that the main sample in Understanding Society or Annual Population Survey could still be used to provide control group data.

- Future research could also seek to build the key missing variables into the analysis (potentially housing costs and quality) so that any confounding effects on life satisfaction are controlled for.

At the end of their paper, by comparing the effect of commute time with the effect of gross personal income in a job satisfaction model, Clark et al (2020) derived a marginal value of £4,080 per 10 minutes of commute time (each way) per annum. Even after netting-off income tax and National Insurance, this suggests a value many times higher than the TAG value for commuting time (or the values in Table 8 from the Krekel & MacKerron happiness approach). We considered whether this could be related to differences in the scope of the value - compared with SP or RP based values in TAG, which tend to capture shorter run behaviours - but were unable to construct a satisfactory argument as to why this would be the case. This issue may require further investigation to understand the causes for the results found.

The field of commuting and life satisfaction is such a central one to transport analysis that it seems to warrant further effort to resolve the outstanding questions above, in particular whether a significant causal relationship between commute time and life satisfaction can be established, and whether the counterbalancing effects of housing costs and quality can be controlled-for and quantified (since those are also of policy interest in a transport-housing-land use context).

Our review findings relating to values of travel time highlight that:

- the existing methods are highly robust (confidence intervals are provided, values are highly reproducible across studies, and there is already cross-validation between SP and RP, etc);

- further conceptual research is needed establishing the extent to which SP and RP based values are expected to overlap with SWB based values, and thereby how the SWB concept of value of travel time is distinct from its traditional counterpart.

- happiness-based analysis offers an opportunity for further validation using another alternative method - initial findings suggest that further validation of the existing TAG values may indeed be the outcome[49];

[49] Initial empirical comparisons suggest that values estimated using happiness data from Krekel & MacKerron (2023) triangulate fairly well with SP-RP based values currently used in TAG (see Appendix 1).

- there is scope for segmentation of the values using SWB (or SP) studies to better represent heterogenous behaviour (and welfare impact) across population groups;

- there is the potential to explore some additional attributes using SWB, such as the interaction with weather and instantaneous travel conditions, and variables such as whether accompanied or not (and by whom). Some of this could be also achieved using other forms of data (e.g. in SP/choice experiments, in some cases with the aid of simulation). On a note of caution, not all additional attributes will produce large wellbeing effects - the main drivers of VTTS are likely to remain the access to opportunity/activities provided by the transport system, and some of the journey attributes already identified as key to the disutility of travel (including unreliability, wait time and crowding).

Health and wellbeing

Health impacts are already valued across UK appraisal, the key components being the value of a quality adjusted life year (QALY) and the disability weights (DW) that determine the determine the QALY impact of a given health state. The QALY value derives from stated preference research (Chilton et al, 2004; HM Treasury, 2022, Annex A1). The DWs derive from international health research (GBD, 2019). On these scales, 1=perfect health and 0=death. Applications within transport include valuation of air quality, noise and physical activity (see below).

An area where wellbeing research brings potentially useful additional evidence is around mental health. Frijters and Krekel (2021) grade the evidence as 'high' for confidence and causality. Clark et al (2020) found a negative relationship - both between individuals and within individuals - between commute time and mental health, the latter measured using the GHQ-12 scale, which is designed to detect symptoms of psychological distress. This effect might then influence life satisfaction - Clark et al (2020) found some evidence that self-reported 'strain' does influence life satisfaction, but the key relationship between commute time and life satisfaction requires further investigation (as discussed in the previous section).

Another interesting result is that poor health causes quantified wellbeing spillovers of around 15% from the person who is unwell to their spouse/partner (Mervin and Frijters, 2014) and potentially to other family members. This remains outside of appraisal practice (in the UK context) for the time being, and the analysis is based on Australian data.

Noise and wellbeing

Transport noise impacts are a promising area for SWB-based valuation. In this case, the appeal is that SWB data potentially captures the full impact on residents directly, rather than assuming a set of impact pathways which - although based on rigorous literature reviews and research - may potentially under- or over-state the total impact. Aspects of the impact may have been omitted *or* conversely some may have been double-counted (e.g.

Many different types of time savings that are valued in TAG, e.g. access/egress time, time in crowded conditions, time spent on business trips of different distances, are not yet valued using the happiness-based method. There are also theoretical questions to be addressed. Nevertheless, the empirics initially appear broadly consistent with the TAG values. This could, of course, turn out to be coincidence once a more differentiated set of happiness-based based values are obtained.

between amenity impacts and health impacts). Figure 5 shows the impact pathways set out in the Defra (2014) valuation report. Despite care being taken to avoid double-counting, Defra (2014, p38) acknowledges that double-counting may still exist, and that the values may not be comprehensive.

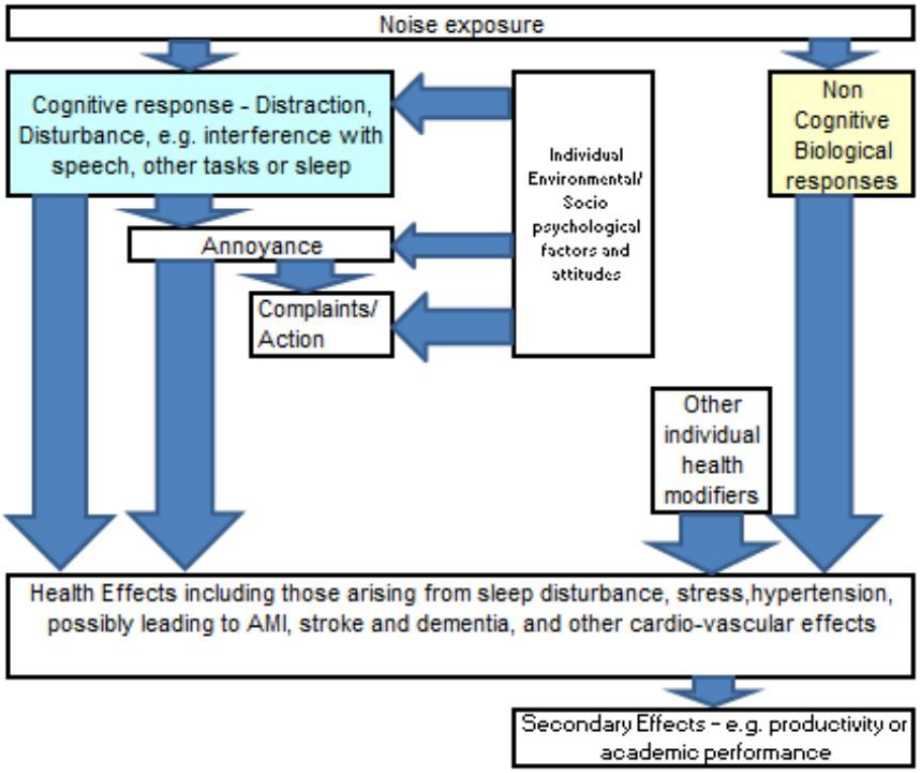

Figure 5: Impact pathway for noise valuation (Defra, 2014)

We reviewed wellbeing-based work by Lawton and Fujiwara (2016) and Scott et al. (2020) in particular. These studies relate to aircraft noise, and a key opportunity would be to expand the scope across modes. The two studies both produce significant empirical results using SWB (life satisfaction) data, however they raise a number of questions.

The first study, Lawton and Fujiwara (2016), produces a constant value across background noise levels, which seems inconsistent with much of the wider evidence (e.g. Defra, 2014; Day et al., 2007; Nellthorp et al., 2007). It also finds a lower threshold of 53dB, which is much higher than the 45dB threshold used in Defra (2014) and TAG (Table 10). Finally, it also fails to find a value for night time noise. Lawton and Fujiwara (2016) produces a life satisfaction effect size of -0.003 per dB, to which we have applied the value of a WELLBY (£13,000 in 2019), adjusted to 2010 prices using standard TAG methods, and multiplied by mean UK household size 2.4 for comparison with the Defra/TAG values.

Method	**Health impact pathway**						**SWB (life satisfaction)**		**SWB (life satisfaction)**	
Source:	TAG Data Book Nov 2023 v1.22						Lawton & Fujiwara (2016)		Scott et al (2020)	
	based on Defra (2014)									
		Direct							TOTAL	TOTAL
	Amenity	AMI	Stroke	Dementia	TOTAL		TOTAL		(WTA)	(via WELLBYs)
53-54dB (daytime)	£28.18	£0.00	£4.51	£6.80	£39.49		-		£172.80	£139.40
55-56dB (daytime)	£31.66	£0.00	£4.55	£6.86	£43.07		£71.76		£442.61	£565.41
61-62dB (daytime)	£41.78	£4.98	£4.69	£7.03	£58.48		£71.76		£2,438.21	£1,843.46

Table 10: Implied marginal values of aircraft noise (2010 prices, per dB/household/annum)

Scott et al. (2020) find effect sizes that are an order of magnitude larger than Lawton and Fujiwara (2016), consequently the marginal values are also an order of magnitude larger[50]. This is true whether the willingness-to-accept (WTA) measure is taken directly from the report (based on the trade-off with income in the model), or whether the effect size is converted to WELLBYS and then adjusted to 2010 prices. We think this calls for further checking and validation.

Other interesting findings which raise questions for further investigation are:

- Scott et al. (2020) find that only 6-7% of the total impact on life satisfaction is transmitted via health - and that is primarily via mental health, they find no significant link via physical health. The comparison with the Defra impact pathways (Figure 4a) is interesting - both seem to suggest that the mental health impacts are more important than the physical, yet it is not clear why these methods are so different in terms of the scale of the total impact, nor whether the physical health impacts are indeed significant.

- Scott et al. (2020) find that night time noise is significant and has an even stronger wellbeing effect than daytime noise (per dB, using LAeq 8hr for night time noise), and starting at a lower noise level, 49dB. Paradoxically, the study does not identify a significant impact on sleep disturbance, though this may be due to small sample size.

- The Scott et al. (2020) values exclude households in the spatial area most exposed to aircraft noise, which are eligible for noise insulation. These households were surprisingly found to have no significant association between aircraft noise and wellbeing. This may be interpreted as indicating that noise insulation effectively mitigates the effects of noise (as the authors do), however this raises questions about noise exposure outside the home (which cannot be entirely mitigated) and whether some other behavioural adaptation is involved.

- There is also an issue of divergence between WTA for a noise increase and WTP to avoid (WTA is greater) – this is simply non-linearity, not loss aversion, most TAG impacts use a CS metric (in between the two), or settle on one metric. The authors suggest that WTA is more relevant for CBA assuming there is a welfare loss, but the intervention could equally be noise abatement regulations (a welfare gain).

At present, the review suggests that SWB evidence on noise valuation could be useful for:

- validation of the results from other methods (including IPA and HP) - again acknowledging that it is important to articulate precisely what is meant by 'validation' in this context;

- considering issues of scope, and whether there is double counting or conversely some omitted value in the IPA-based method - it is not possible to draw any

[50] Note that the study by Dekkers and van der Straaten (2009) cited by Scott et al. (2020, p48) produces a value per annum of €102 per dB per household *per annum*, which is similar to Lawton and Fujiwara (2016) and much smaller than Scott et al (2020). Note also that the income variable in Scott et al (2020) is equivalised, which may have some effect - although probably small - on the Stage I (Income) model.

conclusions on this, given the very small number of studies, making it difficult to fully explain the differences in values emerging; and

- increasing segmentation of the values in future - particularly in terms of modal coverage across all relevant (motorised) modes, but also in terms of any differences in response to noise among the population.

These aims have not been fully achieved as yet, and addressing the questions above would be a useful step towards this.

Air quality values and wellbeing

Air quality has been investigated by a number of studies in the international literature on SWB effects. Two studies that are identified as being of high quality are by Luechinger (2009) and Levinson (2012), and a further study relating to London is by MacKerron and Mourato (2009). There are, however, issues with the relevance of these studies to transport appraisal. In particular:

- Luechinger's study (which is based in Germany), is focused on sulphur dioxide (SO2) emissions, for which the major emitters are power stations and industrial facilities, although transport does cause some SO2 emissions. The current IPA-based valuation method used for transport impacts in DfT focuses on the main transport emissions: nitrous oxides (NOx) and particulates (PM2.5 or PM10)[51].

- The SWB variable in Luechinger's regressions is life satisfaction, however the study sums both the implicit hedonic price of air quality from housing rents and a residual effect on life satisfaction, since housing costs reduce to some extent in areas of poorer air quality (all else equal) - this raises interesting questions about other SWB valuation studies and would warrant further discussion. Transferability of wellbeing effects from a German context would not necessarily be an insurmountable barrier, however the scope issue (SO2 only) remains.

- Levinson (2012) focuses on particulates (PM10), and also carries out regressions including ozone, SO2 and carbon monoxide, which on their own are not significant, although SO2 (only) is significant alongside PM10 with 95% confidence. The data is a large sample from the US General Social Survey (GSS) between 1984-1996, with happiness as the dependent variable. The study controls for weather and precipitation (which affect both happiness as well as air quality) and allows air quality to vary over short periods of time.

- Two limitations of Levison's study are: (i) a potential mismatch of timeframe between daily-varying air quality and happiness more generally "these days"; and (ii) although particulates are especially harmful for people with asthma or other respiratory problems, the GSS dataset did not have data on these conditions, and the proxy variable used instead (self-reported health status) was found to be insignificant.

- MacKerron and Mourato (2009) use a custom-collected survey of around 300 individuals in London, which they acknowledge is too small to produce robust estimates of effects - however their analysis produces an effect size for NO2 which is

[51] DfT (2023) TAG Unit A3

significant with 90% confidence. NO2 and PM10 were highly correlated (Pearson correlation coefficient=0.92) however the NO2 regression was preferred, and the authors acknowledge the resulting effect is likely to be capturing air pollution more generally. They carefully discuss the role of perception in linking air quality with self-reported happiness - this is a key issue for impacts where the full effect on wellbeing may be mediated through perceptions (also see Bickerstaff and Walker, 2001). There is a concern - expressed by Levinson (2012, p879) - that these methods may only be suitable where impacts can be directly perceived. However, if an 'unperceived' effect - e.g. on the respondent's health - is still occurring, we might expect that to influence wellbeing via the health domain (as modelled by the current IPA-based approach).

In summary, although the international literature contains SWB-based values (or effect sizes) for SO2 and PM10 concentrations, these values are not readily applicable in UK transport appraisal for the reasons given above, and are also for other countries (Germany and the US) - so some benefit transfer work would be required (though transferring SWB effect sizes would alleviate one aspect of that). The number of studies remains relatively small, and MacKerron and Mourato (2009) point out the difference in magnitude between the effects of NO2 measured in different studies (a factor of roughly five). An SWB-based method could be used to derive air quality effect sizes in the UK, with the aim of cross-checking the existing Defra IPA values. We have no expectation at this stage that the results would materially differ from the IPA, however issues of perception and timeframe could cause the values to diverge. The SWB approach might provide a useful check on the inclusion of both NO2 and particulates in the values - however the perception issue would need to be resolved in order to know which approach is preferred. The potential is therefore - rather like noise - mostly to validate (or revise) and potentially segment the existing values further, if new empirical research was undertaken.

Accessibility and wellbeing

Accessibility is addressed in TAG in two principal ways:

- Accessibility is part of the analysis of travel demand (see the TAG 'M' units) which informs the assessment of user benefits and wider impacts (TAG Units A1.3 and A2 family) and consequently a range of other impacts[52]. The user benefits are reported in relation to Commuting and Other Non-Work travel, and separately for all Business travel (Table 1). These are monetised impacts, contributing to the NPV and BCR measures of public value and value for money (Section 1).

- Accessibility is also a Distributional Impact (DI) in TAG: there is a focus on providing "a holistic approach to considering the accessibility needs of different groups of people, taking into a wide range of factors, including journey times to reach key destinations, service frequencies and provision of accessible boarding at stops". The key destinations addressed include employment centres, educational and healthcare facilities, recreation and leisure facilities, shopping and social amenities[53]. The social groups considered in DI analysis in TAG were introduced in Section 2 above. After

[52] Accessibility measures such as those deriving from Hansen (1959) include a measure of the deterrence or disutility of travel to opportunities at different destinations (e.g. Handy and Niemeier, 1997) - this drives the trip generation/trip end stage of transport models as well as behavioural responses such as changes in mode, route and destination, and is measured by generalised cost or generalised journey time for appraisal purposes.

[53] DfT (2023) TAG Unit A4.2, p57

investigation and assessment, these impacts are scored on a 7-point scale and are included in the Appraisal Summary Table.

In the SWB evidence to date, Chatterjee et al. (2019) is a key source on the wellbeing impacts of accessibility. The authors conceptualise the relationships between accessibility and society for different social groups as shown in Figure 5a. Data used was from Understanding Society and the English Longitudinal Study of Ageing (ELSA), and the analysis includes both cross-sectional and longitudinal regressions, with a sample size greater than 20,000 observations in England. Key findings from the study are:

- Personal access to a car is shown to increase access to services and other opportunities, particularly for those living in rural areas and people with mobility impairments. Access to a car also appears to have a minor positive role in positive mental health outcomes and to reduce loneliness in those aged over 50. However, it did not prove possible to establish a significant link with the overall SWB measure, life satisfaction.

- Perception of public transport services "in your local area"[54] was found to be a significant positive influence on life satisfaction, including in longitudinal analysis, indicating a causal relationship[55]. The intermediate variables access to services (+), mental health (-) and strain (-) were also significant, with the expected signs. This subjective rating variable for public transport services was found to be more powerful than an objective measure of bus accessibility (e.g. walk time to bus stops), and in this study the latter was not found to have a significant impact on life satisfaction. The size of the impact is expressed in terms of an increase by the factor 1.3 in the probability of becoming dissatisfied with life, for people who shift from excellent/good to fair/poor public transport provision.

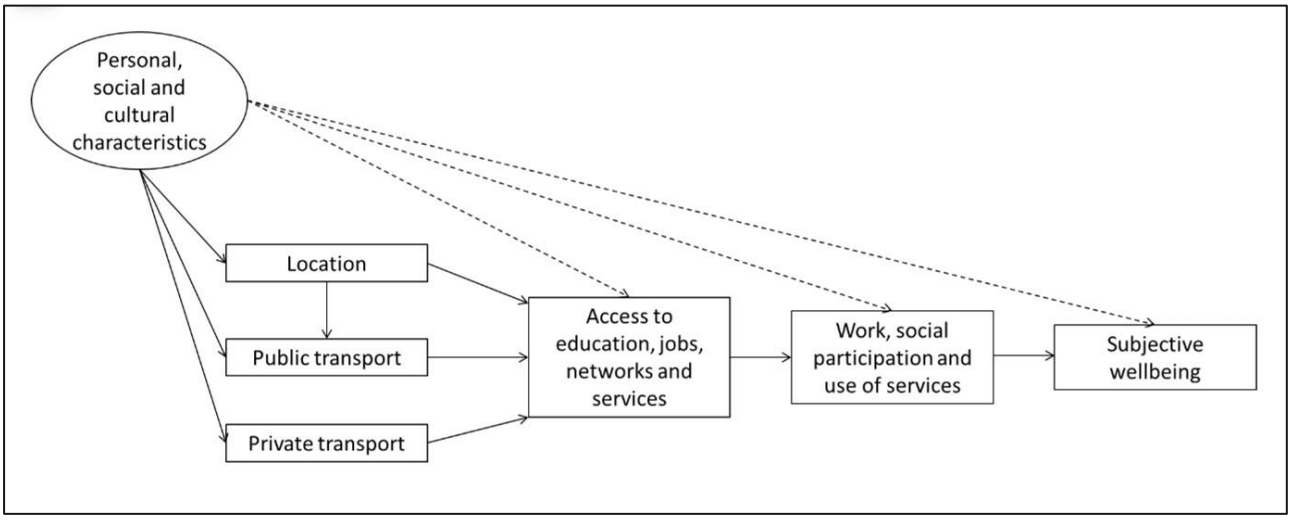

Figure 6: Conceptualised relationships between different social groups, transport, access to opportunities and subjective wellbeing (Chatterjee et al., 2019)

[54] The question in Understanding Society is: "How would you rate public transport services in your local area?" on a 4 point scale from excellent to poor, which was reduced to a binary variable for the regression analysis: excellent/good or fair/poor.

[55] The longitudinal relationship was found to be significant at 95% for decreases in public transport provision and just below the 95% significance threshold (p=0.063) for increases in public transport provision.

Chatterjee et al. are able to show how parts of this impact pathway are supported by the wider literature. In terms of UK evidence, this is the key study providing quantitative evidence on the value of accessibility in terms of SWB.

In considering the implications for TAG, it is important to note that:

- This study provides important insights for the purposes of DI analysis: on the role of perception of local public transport services in wellbeing - both in the overall indicator life satisfaction, and in the health domain, specifically on mental health indicators; and on the role of car accessibility, particularly in rural areas, and particularly for those with mobility impairments and people aged 50+.

- For the purposes of valuation, the study points also towards potential sources of differentiation in values - for people with mobility impairments, those living in rural areas, over 50s and people with no car available. It is important to note that:

    - The social value of bus provision is addressed in TAG (Data Book Tables A1.3.16-18)[56] based on SP methods - this identified the marginal value of bus service provision for those who would "not go" if the service was not provided. These values reflect differences in concessionary pass-holding, area types, car ownership and trip purpose - as such they do cover much of the differentiation identified in Chatterjee et al. (2019).

    - However, the Chatterjee et al (2019) study points also to the role of overall perception of public transport services in the local area - this would naturally include quality of service as well as provision, and would include urban light rail & metro systems, National Rail services, and potentially services such as demand responsive transport and community transport, and taxi/ride-sharing availability, which may be important in meeting the types of needs identified.

    - In TAG the 'social value of bus provision' values are treated as providing greater detail on the distribution of benefits from an intervention, rather than additional value[57].

- TAG also includes evidence on option and non-use values. These include the value of provision of public transport services over and above their expected use - including both a form of 'insurance' against the uncertainty of future mobility needs and capabilities, and (a smaller item) an altruistic component relating to the availability of the service for others[58]. These items are additional to user benefits, and are currently not differentiated by user type or area type, but are differentiated by mode (rail/bus). Since these form part of the total value of public transport provision, any attempt to reconcile evidence emerging from SWB studies with current TAG values would need to consider the role of option and non-use values.

As part of this study, a discussion was held with members of DPTAC (Disabled Persons Transport Advisory Committee) and Transport for All, for whose time the authors and DfT are very grateful. This discussion highlighted that:

[56] Evidence source is Mott MacDonald (2013)
[57] TAG Data Book, Table A1.3.18
[58] see DfT (2022) TAG Unit A4.1, Section 7

- It will be important to explore and recognise the different accessibility requirements of people with different disabilities, and the intersection with people's wider circumstances and the travel context, e.g. people with disabilities *and* travelling with luggage, and thinking widely about how people with disabilities access a range of opportunities[59].

- It is important to consider levels of satisfaction with the transport services provided, not only the achievement of a minimum standard of provision (this links to work on satisfaction by Transport Focus, for example). Another useful concept is that of confidence - to what extent do transport services provide disabled people with a complete service they can be confident in (avoiding stress and anxiety associated with various gaps and failures in service provision)?

- There is some scoping research on valuing Access for All interventions on the railways - this emphasises the need to measure difficulty of travel relative to each individual's capabilities, and also the value in looking at demand uplifts from improvements (additional journeys that would be unlocked) (Ojeda-Cabral et al, 2023).

- Specific interventions may have specific impacts on access for all and wellbeing (e.g. concessionary fares, or street design for people with visual impairments). Targeted evidence-gathering would be needed.

- Surveys could frame their questions about disability better - e.g. enquiring about different disabilities or capabilities, and avoiding a narrow question suggesting a medical-model focus. Boost surveys may be a useful way of expanding key national datasets to allow greater segmentation.

In summary, this is in interesting and important area, spanning the monetised (VfM) and distributional analysis (DI) aspects of TAG. SWB research to date gives some indication of directions for further investigation, while at the same time a review of current TAG evidence gives grounds for caution (not to assume that SWB benefits are additional). Indeed, the most promising avenue to pursue may be to better understand the differentiation in the welfare/wellbeing impacts of transport by social group, including people with disabilities (and including quantification and valuation), allowing appraisal values to better reflect the tailoring of interventions towards people's identified needs.

Biodiversity, greenspace and wellbeing

Biodiversity impacts are not currently valued in TAG, although a non-monetised assessment of biodiversity impact is included, and the method leads to score on a textual scale: Major negative/Intermediate negative/Minor negative/Neutral/Positive[60].

A research programme is underway, focusing on modelling and economic valuation of biodiversity, funded by NERC (Natural Environment Research Council)[61]. Within the NERC programme, there are different strands relating to multi-functional urban environments,

[59] One specific point raised is that access to social networks is very important (see also Table 14 below) and will be important when thinking about wellbeing valuation.
[60] DfT (2023), TAG Unit A3 Environmental Impact Appraisal
[61] https://www.ukri.org/what-we-do/browse-our-areas-of-investment-and-support/economics-of-biodiversity/

decision support tools, valuation and additionality. Notably there is a set of projects focusing on the mental health and wellbeing benefits of nature engagement through measures of soundscape complexity. These studies are due to report in 2025-6. When this research reports, it may have implications for urban design and for townscape impacts in TAG, e.g. from improved 'green infrastructure' such as street trees and parks/parklets, as well as from any loss of biodiversity due to construction impacts. There is also a link to the noise component of appraisal, since one recognised opportunity to improve noise valuation in public spaces is to recognise that noise is part of - and its impact varies with - soundscape as a whole, which may contain a mix of positively-perceived and negatively perceived sounds[62]. Biodiversity is one of the impacts currently valued by Defra using an ecosystem services (ES) approach[63], with a relatively complex impact pathway, therefore when any SWB-based valuation results become available, they will likely be used to update existing ES-based values.

Related to biodiversity (and also to the Townscape impact in TAG) is the amount of green space in a local area. By green space, we mean the use of land, specifically for parks and other areas dominated by vegetation. The main SWB studies on green space in the UK (White et al, 2013, and Alcock et al, 2014) include private gardens in their analysis as well as public green spaces, although not all analysis does so - public green space might have quite different distributional impacts from private green space. Empirically, White et al. find a different (smaller) coefficient when they exclude gardens. The main life satisfaction study for the UK (White et al, 2013) uses panel data regressions on BHPS data, including individual fixed effects. The data includes households who have moved to areas with different amounts of green space - although this does not represent an exogenous change in the policy variable. The findings are the expected sign - showing that increasing amounts of green space within the local area[64] have significant (at 95% confidence) positive impacts on life satisfaction, consistent with the extensive health literature on the same topic.

The study by Bertram and Rehdanz (2015) adds two useful insights: (i) that the effect of green space on life satisfaction is not linear, but U-shaped; and (ii) the positive effect of green space is largest for an area coverage of 11%. Using data for Berlin, the authors find that 75% of residents have less green space than they would like.

The study by Carrus et al. (2015) indicates that green spaces with greater biodiversity are more positive for wellbeing - in other words there is some complementarity between wellbeing effects of biodiversity and of green space.

Increasing green space is not usually a direct policy aim in transport, although in an integrated transport-land use planning context it may well be. Avoiding reducing green space may be a concern for new infrastructure construction.

Construction/maintenance and wellbeing

Evidence is limited so far, however Fujiwara et al. (2018) investigated the wellbeing impact of roadworks on behalf of Anglian Water. They used the Annual Population Survey (APS) data on life satisfaction from 2011-16, and found a significant effect on respondents living

[62] e.g. Jiang and Nellthorp (2020)
[63] Defra (2023). Enabling a Natural Capital Approach guidance
[64] the local area in the data is a Lower-Level Super Output Area (LSOA)

within 500m of a road works incident, over a period of 1 month (they investigated distances between 50-2000m of the respondent's home postcode, and time periods from 7-730 days before settling on this as the best spatial and temporal frame).

Item	Value
Per incident per household potentially affected wellbeing value	£40
90% CI – lower bound	£0.50
90% CI – upper bound	£79
Number of households affected by incident	795
90% CI low	721
90% CI high	869
Aggregated wellbeing value of incident	£31,735
90% CI low	£358
90% CI high	£68,887

Table 11: Valuation of roadworks incidents within 50-2000m of home postcode (Fujiwara et al., 2018)

Table 11 shows the results. The average wellbeing effect was -0.011 per incident per person, or -0.027 per incident per household, lasting for one month (as above). The authors convert the wellbeing effect to a monetary value using:

Monetary value per person = Marginal Rate of Substitution, $MRS = \frac{\beta_Q}{\beta_M}$

where β_Q is the wellbeing regression coefficient on roadworks incidents, and

β_M is the wellbeing regression coefficient on income.

The income coefficient, β_M, is taken from a separate study (Fujiwara and Dolan, 2016; Fujiwara, 2013). This gives a total value per incident of £31,375, which is markedly different from a disbenefit of £9,973 calculated using TAG values of travel time savings.

Other impacts and wellbeing

- **Option and non-use values.** The notion that a dependable transport link or service has value in itself, leads into a discussion of option value (OV) and non-use value (NUV), which are already captured within TAG (and were introduced above). The values in TAG are based on a synthesis by Laird et al (2006,9) of three studies: Humphreys and Fowkes (2006) and Bristow et al (1991) using CVM; and Geurs et al (2006) using SP. The questions are framed in terms of overall value, over the year ahead. These studies showed that the value of being located near to a rail station or other public transport node exceeds the expected use value - i.e. the sum of the expected user benefits and fares paid. The additional OV and NUV are given for rail and bus modes in TAG Data Book Table A4.1.8. Two of the underlying studies report confidence intervals, and these are not out of line with other TAG impacts. However OVs and NUVs are grouped in the least robust category of impacts in the DfT Value for Money Framework (DfT, 2017). One aspect of the values that could be refined further is their sensitivity to service frequency. The underlying research (Humphreys and Fowkes, 2006) shows greater values at higher service frequencies for rail. A notable gap in coverage is that other modes such as light rail/tram/metro are not addressed.

- A potential link between wellbeing and option values has been made by Mele et al. (2023). In our view, this link would seem intuitive, but this line of work would seem to be at a (very) formative stage. It would also seem feasible to further refine the values using SP, CVM or HP (a recent study, Bondemark et al., 2021, explores OV and NUV for different service frequencies and for different levels of accessibility, and produces empirical results for part of Sweden, using property price data and HP).

- **Historic environment.** The Department of Culture, Media and Sport (DCMS) has embarked on a major programme of work on valuing culture and heritage capital (Sagger et al, 2021)**.** There has been a scoping review, which has found a large body of evidence linking heritage sites with wellbeing, though we were not able to identify quantitative research findings linking access to, or transport impacts on the setting of, historic sites, with the ONS4 wellbeing measures (What Works Wellbeing, 2019). This is an area where we could expect to see SWB-based values to emerge in future. There is also a potential overlap with natural capital and ecosystem services, since some historic sites are co-located with green spaces.

- **Regeneration.** Dolan and Metcalfe (2008) examined the wellbeing impacts of a place-based regeneration project in this exploratory study. Although the findings are almost certainly not transferable, the study addresses many salient empirical issues

in the evaluation of regeneration, including reasons for differences between SWB, SP and HP values.

- **Personal security.** The social costs of crime and antisocial behaviour are already measured in research for the Home Office (Heeks et al., 2018), and are used from time to time in transport appraisals where reductions in crime/antisocial behaviour are expected to be significant benefit. These values are based on a mixed methods approach including some use of a health impact pathway approach (IPA) with disability weights (DW) for injuries and harm sustained from Salomon et al. (2015) and some use of stated preference (SP) for non-violent crimes. This evidence is used to produce a value set which covers different crime types and includes costs in anticipation of crime, as a consequence of crime (costs to the victim), and costs in response to crime (policing and justice).

- There is now wellbeing-based research on the welfare costs of crime, including the fear of crime and the experience of being a victim of violent crime (Hanslmaier et al., 2013; Johnston et al., 2017). This expands the scope of the current values to include fear of crime (and the factors which increase fear of crime). This an area where some UK-focused research would help to ground the evidence in the UK context. There is relevant data from the Crime Survey for England and Wales (CSEW) on the impact of being a victim of crime on the ONS4 wellbeing measures (Flatley, 2015, Chapter 3). For example, this data shows a significant reduction in the probability of being satisfied with life (>6/10 on the 0..10 scale) from 74% to around 54% for those aged 16 to 59 who have experienced violent crime.

6. Current valuation approaches and SWB – strengths, weaknesses and potential complementarity

Approach

As requested by DfT, we have focused on identifying which areas have the greatest potential for using wellbeing-based economic valuation approaches, and in which areas there are limitations to the use of wellbeing approaches for transport appraisal.

To do this methodically, a set of criteria were developed, taking into account the principles underpinning TAG as well as evidence standards used by DfT[65] and across government[66]. The valuation methods used currently in transport appraisal, together with the potential use of SWB-based methods, are assessed in this chapter against these criteria, in terms of:

- strengths and weaknesses of the valuation methods in relation to these criteria;
- the potential for complementarity between SWB-based and existing methods, in a number of ways.

Criteria as a basis for comparison

The following criteria were developed, based on existing principles and evidence standards used by DfT and in the wider literature. Together these are intended to represent the *robustness* of the values - all four are regarded as important.

1. Causality. A key requirement running through the literature and the official guidance, including the Green Book supplementary guidance on wellbeing, is the demonstration of causality. Causality is the focus of the Maryland Scientific Methods Scale, which was adapted to the transport context in the What Works Centre evidence review for transport[67]

[65] e.g. defined in the Evaluation guidance (DfT, 2020 *TAG Unit E-1 Evaluation*)
[66] e.g. HM Treasury (2020) *Magenta Book*
[67] WWCLEG (2015)

and is cited in the TAG evaluation guidance[68]. It needs to be shown that the effect measured is not only associated with the claimed causal variable, but is caused by it. There are many potential confounders, which could cause variation in multiple observed variables, and in some cases reverse causality is possible. To avoid these issues, a range of research methods are available including use of control variables in regressions, comparison of suitable treatment and control groups, difference-in-difference methods, and quasi-experiments using panel data and instrumental variables. Another solution is to include the effect explicitly as a variable in hypothetical questioning methods such as SP. In addition, causality can be evidenced (arguably to a lower standard) by establishing impact pathways and providing a range of evidence to demonstrate that these pathways - and not others - are the transmission mechanisms for impact.

2. External validity and reproducibility. Routinely, this is the assessment of whether the relationships estimated between causal factors and outcome indicators can be generalised beyond the setting of the specific study, e.g. to other population segments, other geographical areas, and other points in time. This may be addressed by gathering a large enough sample size within the study, and ensuring adequate segmentation and representativeness. In some cases, it may be addressed through benefit transfer methods, taking advantage of wider evidence on the variation of the value to extrapolate to other contexts. Beyond this, the question of reproducibility or replicability of results is discussed more often in the natural sciences literature than in social sciences[69], but is sometimes alluded to in transport modelling and appraisal. Meta-analysis studies help to demonstrate that values are reproducible. The 'plausibility' of a new model or study finding is often discussed in relation to the existing body of evidence (e.g. marginal values of travel time by trip purpose/context). The valuation literature also recognises the potential for changes in values over time, driven by wider technological, social or economic trends - such as changes in values of travel time with the development of digital mobile connectivity (e.g. Batley et al, 2017). Therefore the assessment of external validity is a subtle task, and one that would typically take into account the design of the individual study, the wider range of conditions in the country, and an understanding of the wider evidence on variation of that particular value over space, time or population segments.

3. Scope (completeness and double-counting). The key issue here is whether the scope of the value matches the scope of the effect on human welfare/wellbeing. For example, the noise values developed by Defra (2014) cover amenity, direct AMI (acute myocardial infarction), stroke, dementia and sleep disturbance. This is based on an impact pathway approach, carefully developed, in which each branch of the impact pathway is supported by evidence. There are two questions around this: (i) whether there is any effect which has not yet been included in the impact pathway and therefore is omitted from the scope of the values[70]; and (ii) whether the valuation method double-counts any aspect of the welfare impact - in this case through the use of multiple branches in the impact pathway which

[68] DfT (2022) TAG Unit E-1

[69] although there is some coverage of it in the economics literature, e.g. Hamermesh (2007) 'Replication in labor economics'

[70] Jiang and Nellthorp (2020) note that the values are based on noise experienced at home, while noise experienced in public spaces, including streets, is omitted from the scope of the impact.

may be measuring the same welfare impact through more than one channel or method[71]. A further issue is whether the values cover all necessary transport contexts, in particular:

- modes of transport;
- trip purposes.

Capability to value hypothetical changes, outside the range of existing data, is an advantage for SP and hypothetical questioning methods. This helps with the valuation of new technologies and improvements beyond existing attribute levels.

4. Accuracy. Within a study, accuracy may be demonstrated through estimation of confidence intervals, transparently reported. Even if confidence intervals are wide, their estimation gives the analyst - the appraiser in this case - the opportunity to assess accuracy and to conduct sensitivity tests to the value in question[72]. Across studies, meta-analysis can provide confidence intervals, such as those in meta-analyses of values of travel time or public transport service quality[73].

Strengths and weaknesses of valuation methods

Table 12 provides general findings on the strengths and weaknesses of valuation methods already adopted - or with the potential for adoption - in TAG.

Method	*Strengths*	*Weaknesses*
SP, DCE, CVM	1. Accuracy. Found to be high when applied to travel attributes, particularly values of travel time savings and journey quality. 2. External validity and reproducibility. High, provided that - as discussed above - relevant contextual variables are controlled for. 3. Scope. Can be tailored very closely to the exact scope of the impact we seek to measure. Able to address technologies and attribute levels outside of current data. 4. Causality. The effect is included in the attributes in the choice experiment - establishing causality in the mind of the subject. This makes for an efficient data gathering approach.	3. Scope. Reliant on human perception, and therefore limited by, e.g., the known difficulties of accurately perceiving (sensing) some air pollutants or all the health impact pathways for air quality/noise. Risk of strategic and hypothetical biases, framing effects and part-whole biases, which are carefully managed in most current experiments. Presentation of hypothetical scenarios/levels requires care/realism to obtain robust values.
RP - transport and property market data	1. Accuracy. High when applied to travel attributes, particularly values of travel time savings and journey quality. More observations may be required than in SP due to confounded effects , e.g. a faster journey may also be cheaper.	

[71] e.g. in the case of noise, the main concern is whether the amenity values capture and therefore double-count some of the health impact, through individuals perceiving the health impact and then taking it into account in their housing market choices or any other expression of their perceived amenity.

[72] The range estimated for the marginal abatement costs of carbon is a good example of this (TAG Data Book, Table A3.4). The confidence intervals on the value of travel time savings in TAG Unit A1.3, Section 4.3, is another.

[73] Wardman et al (2016); Wardman (2014)

	2. External validity and reproducibility. High, provided that relevant contextual variables are controlled-for. RP+SP approaches may achieve the best possible result. 4. Causality. Methods indicated above may be used.	3. Scope. May be limited by the market data collected. Of particular relevance is the lack of individual contextual data on the person in market datasets, which makes segmentation and behavioural analysis more difficult. Can only value attribute levels experienced within the market (not suitable for hypotheticals).
SWB	1. Accuracy. Studies to date indicate accuracy may be comparable to existing methods in certain contexts. 2. External validity and reproducibility. High, provided that relevant contextual variables are controlled for. 3. Scope. Ideal, in the sense that it maps onto the variable of policy interest (welfare, wellbeing metrics), and can relate wellbeing effects to personal characteristics of respondents not always available in RP data. May not be as efficient as SP/DCE/CVM methods, which are able to target the precise impact of interest - provided that impact can be isolated sufficiently for analysis purposes.	4. Causality. As with RP, methods indicated need to be used to establish causality. Underlying datasets typically do not study the impact of (transport) interventions on SWB, but instead rely on potentially spurious cross-sectional comparisons.

Table 12: Strengths and weaknesses of valuation methods

Turning to the specific impacts for which there is SWB evidence (reviewed in Section 5), we assess to what extent the evidence for each of them meets these criteria. The findings are shown in Table 13.

	Impact & Component	Causality	External validity and reproducibility				Scope	Accuracy	Comments
			Consistency of findings	Number of studies (few/multiple)	UK	Whole UK?			
Economy	User benefits: Business travel time	- (Business VTTS not specifically addressed in Krekel & MacKerron, 2023 - see Commute/other time savings below)							
	Regeneration	Good (Quasi-experiment with exogenous regeneration effect).	-	Few	✓	✗ Hafod, Swansea.	Only one package of regeneration measures (among many possibilities).	✓	Dolan and Metcalfe (2008). Shows how a small, customised sample (N=364) can be used efficiently.
	Wider Impacts - Income	Good (Individual fixed effects (FE) models, though endogeity issues widely discussed).	Good	Multiple	✓	✓	✓	✓	Some concern around comparison effects.
	Wider Impacts - Employment	Good (Models based on localised or generalised employment shocks, controlling for likely confounders).	Reasonable consistency - though different across groups and contexts	Multiple	✓	✓	✓	✓	
Environmental	Noise	Fair (Panel data regression, with main SWB determinants controlled-for and local authority fixed effects).	Inconsistent with IPA and HP values, and between studies.	Few	✓	✗ Focused on Heathrow, Gatwick, Stansted.	Aviation noise only (day and night).	✓	Scott el al (2020) in particular.
	Air Quality	Good (Individual fixed effects (FE) models, with exogenous variation over days).	Not yet a consistent effect size	Multiple	✓	✗ London.	Need to address combined impact of NOx and PMs.	✗ Significant at 90% confidence (MacKerron & Mourato, 2009).	
	Townscape/Biodiversity - green space	Fair (Individual fixed effects (FE) models, though lacking exogenous changes).	-	Few	✓	England	✓	✓	Bertram and Rehdanz (2015) find U-shaped wellbeing relationship.
	Historic Environment	Not demonstrated for access to, or setting of, heritage	-	Multiple	✓	✓	Contextual evidence on visiting and living near heritage sites. Impact on the setting of heritage sites not	-	Research on value of cultural and heritage capital being commissioned by DCMS.
Social	Commuting and Other users	Good (Individual fixed effects (FE) model).	Reasonably consistent with SP/RP values on first inspection.	Few	✓	✓	✓	✓	Krekel and MacKerron (2023) in particular.
	During construction and maintenance	Good (Model based on roadworks incidents, timeframe and spatial effect endogenously determined).	-	Few (Only one study).	✓	✗ Anglian Water area covers urban and rural locations, though not London.	Not all types of roadworks; motorways and trunk roads probably under-represented.	✗ Just significant at 90% confidence.	
	Security	Good (Victimisation is an exogenous variable, controls are in place).	-	Few	✗	✗ Berlin, Germany.	✓ Expands the scope to include fear of crime - a key gap.	✓	Hanslmaier (2015) in particular.
	Access to services	Fair (Longitudinal analysis with controls on SWB determinants).	-	Few	✓	✓	Findings relate specifically to the total value of public transport services (rating) in the local area.	✓ >95% confidence for decreases in PT provision, 93.7% for increases.	Chatterjee et al (2019).
	Option and non-use values	Conceptual framework and narrative interviews only.	-	-	-	-	-	-	Mele et al. (2023).

Table 13: SWB evidence quality by TAG impact

Our interpretation is that income and employment are the closest to being ready for application - they broadly meet all four criteria, though with a few caveats in each case. Values of travel time savings are in widespread use in TAG already, and here the happiness-based evidence promises to provide some further validation of the SP/RP-based values, and potentially increased segmentation.

For other impacts, the SWB evidence currently available tends to fall short in terms of:

- a lack of external validity & reproducibility: often there are too few studies to conduct meta-analysis or to establish a reasonable level of consistency across studies; or there are apparent inconsistencies between studies; or there is insufficient UK-based evidence so far, or data only for specific areas of the UK which may not transfer readily to other area types;

- scope: e.g. for noise, evidence only addresses aviation noise, omitting other modes; and for air quality there is no high quality study valuing NOx and particulates together, applicable across UK regions;

- accuracy is less concerning than the above (most of the published work cited in the table achieves significance at 95%, and confidence intervals in many cases are comparable with existing TAG impacts);

- causality: a major concern in compiling the table was to focus on evidence that can demonstrate causality, and many other studies (and other models within the same studies) were unable to make a clear case for causality.

Nevertheless, there is promising research not only for income and employment, but also for: noise; air quality; green space; disruption during construction and maintenance; accessibility; and personal security. Perhaps also for regeneration, heritage impacts, other aspects of biodiversity, and option values - though these are perhaps further away from producing values that would meet the four criteria above.

Potential complementarity of valuation methods

We were asked to consider whether/how SWB methods could be complementary to the existing TAG values. Summarising from the above, we infer that the existing SWB valuation evidence shows:

- SWB methods may be suitable for validation of values derived using other methods - e.g. there are early indications that values of travel time savings based on momentary happiness data may be reconciled with values based on SP and RP data (see above), and it is possible that this may extend to other TAG impacts in future;

- For the above to be true, however, additional conceptual research is needed determining the extent to which convergence of values is to be expected across valuation methods.

- 'Top down' SWB evidence may be particularly useful to help validate values which are developed from the bottom up, e.g. IPA-based values for noise and air quality;

- In some cases, SWB methods may be able to expand the scope of the impact in useful ways, e.g. to include the fear of crime in personal security, and to develop values for greenspace and local biodiversity;

- They may help to segment VTTS and other values by more personal characteristics and more travel conditions. This may be helpful in constructing more 'agent-based' models and conducting more 'person-centred' appraisals - at least, appraisals better reflecting heterogeneous responses to particular impacts;

- There may be scope to operationalise distributional weighting in relation to wider impacts and affordability, particularly where these can be related to income segmentation.

Timeframe and levels of welfare measurement

Values derived from SWB data (on different SWB metrics) could also be complementary to SP and RP-based data due to the different timeframes and levels of welfare measurement that they provide. Life satisfaction data is appealing as an overall measure, addressing 'your life' at present. This is distinct from the ONS happiness data, for example, which relates to 'yesterday' and the Mappiness data used by Krekel and McKerron (2023) which relates to momentary happiness, at the time when the respondent is alerted by the app.

How do these relate to SP and RP data? Some SP data used in deriving TAG values (e.g. for journey time, journey time multipliers) is for trip level choices: mode; route; departure time; and so on. Such choices are presumably made partly at a 'day' level - e.g. how am I going to get to work today - and partly at a momentary level - e.g. since my train is running late how shall I complete the last stage of my journey? However, not all SP-based values in TAG are based on trip-level or day-level questions. Casualty values, for example, are based on values for change in health state derived using SP - these are for the longer term (the forseeable future). Option and non-use values are from SP questionnaires focusing on the total value of having a station or public transport service available nearby. Meanwhile, RP data from hedonic pricing studies in the property market is driven by residential choices including home location, home type and size. SP data can also be for location choices, e.g. discrete choice-based LUTI models for example (e.g. Geurs et al, 2010), and also the value of travel time (e.g. Dubernet and Axhausen, 2020)

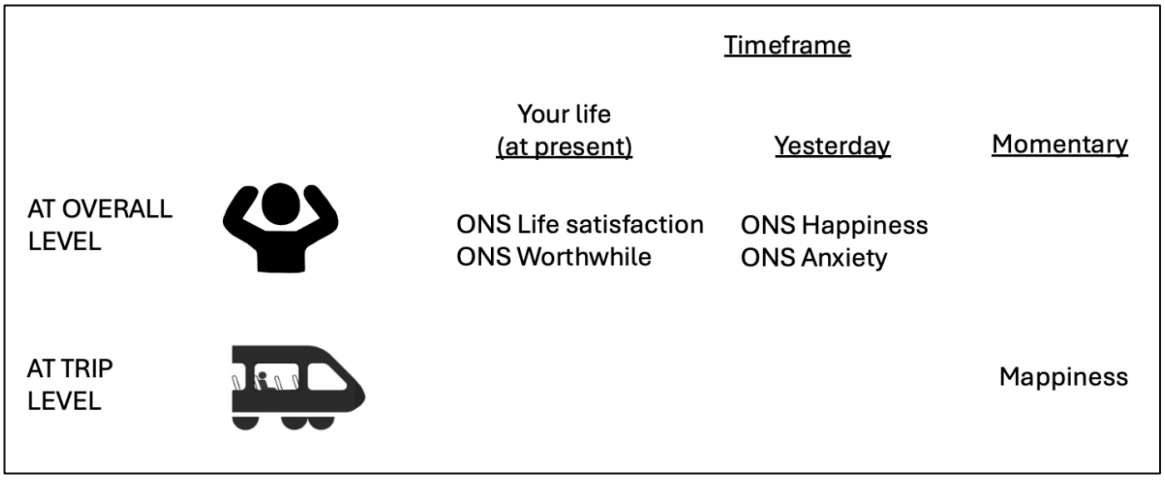

Figure 7: Overall versus trip-level wellbeing metrics and timeframe (present/day/moment)

Going forward, it may be important to consider:

- where SWB data could help to capture the overall impact - and the long-term impact - more easily than building up from many detailed and complex activities (which models may struggle to represent - e.g. activities at various destinations over the course of a day/week);

- conversely, where SP/RP data already captures the whole impact by building it up from components - e.g. this is potentially the case with user benefits + option & non-use values, capturing different components of the value of transport provision. Validation using SWB evidence, particularly effects on life satisfaction, may help to increase confidence that the bottom-up analysis has captured the full impact. The experience to date with noise, VTTS and other impacts (in Section 5) suggests that there is more work to be done before life satisfaction-based and SP/RP/IPA-based values can be fully reconciled.

The duration of the effect is also an important consideration for some impacts - e.g. for security impacts (welfare impacts of changes in crime), the duration of the QALY effect on quality of life *after* the crime incident is defined in the Home Office values (Heeks et al., 2018). For some impacts, the evidence indicates that the effect lasts as long as the causal factor is present - effects in this category include unemployment, and probably noise. Adaptation can occur, and the extent and rate of adaptation are part of more advanced analyses of wellbeing effects. Overall, a better understanding of the dynamics of wellbeing impacts is an important part of the wider research agenda.

7. Applicability of SWB in TAG modelling and appraisal

In general, the role of *modelling* is to forecast the quantity outcomes (e.g. trips, journey times, distances, levels of crowding, accidents, etc), while *appraisal* values these outcomes. Subjective wellbeing (SWB) prompts us to think afresh about how transport interventions impact on people's quality of life, and how those impacts might be:

- predicted, through modelling;
- valued, in the appraisal.

That is the focus of this section of the report. We begin by asking 'What drives SWB in transport'? We then discuss current TAG modelling and appraisal, the applicability of SWB evidence and methods.

What drives SWB in transport?

The literature contains a great deal of evidence on what drives people's wellbeing[74]. Table 14 lists eight key drivers expressed in general terms - these are broad 'domains' such as health, income and so on. In each case, the strength of the link between overall life satisfaction and people's satisfaction with the specific 'domain' is given, from Layard (2016). We also give examples, in the final column, of how transport impacts on these aspects of wellbeing.

[74] see e.g. Frijters and Krekel (2021), Layard and de Neve (2023)

Wellbeing domain	*Strength of effect on life satisfaction, $\delta LS/\delta X$*	*Transport impacts - examples*
Social life	0.194	Accessibility (transport) to a person's social network
Use of leisure	0.174	Time spent travelling to/from activities
Health	0.172	Physical activity, related to the amount of active travel undertaken; Health impacts of air pollution and noise; Fatalities and casualties
Relationship (spouse/partner)	0.171	Long commutes - reduce family time
Income	0.110	Income changes due to productivity impacts
Job	0.086	Employment impacts
Housing	0.070	Noise impacts at home from transport
Amount of leisure time	0.070	Commute time, business travel time and leisure travel time changes

Source: first two columns adapted from Layard (2016); third column - own work. Notes: observations N=107,501 and R-squared=0.740 for the effect of domain satisfactions X on life satisfaction LS.

Table 14: Key drivers of wellbeing and their relationship to transport impacts

As Table 13 shows, the impacts in TAG relate to some of the most influential factors in wellbeing. TAG impacts which are not specifically mentioned in the table - for instance, reliability, townscape or option value - can also have impacts on wellbeing, as discussed in this report. Table 14 is simply a list of some of the strongest influences on wellbeing, by domain, not a complete list of effects on wellbeing.

In order to estimate the welfare impact of transport interventions, the impacts of transport such as those in the final column of Table 14 are subject to modelling - the modelling leads to quantitative predictions, e.g. of changes in travel times, accidents, noise, air quality, and physical activity. The quantity outcomes are then valued in appraisal. The appraisal values are currently based on a range of valuation methods outlined in Section 3, and in a few cases based on SWB evidence as described in Section 5 above. We unpack the modelling stage further below.

It is worth noting, when considering Table 14, that accessibility - mentioned in relation to 'social life' in the table - currently features in TAG in two ways: (i) improvements in accessibility are usually measured through reductions in generalised cost of travel, and hence appear as part of the User Benefits in TAG[75]; (ii) there is also a TAG impact specifically on Accessibility, which focuses on the distributional aspect of accessibility. Accessibility is an important focus of transport planning and it is often argued that wider use of quantitative accessibility measures throughout transport analysis would be advantageous[76] - taking this idea forward could lead to the estimation of wellbeing measures based on accessibility. Eliasson (2020) discusses the reconciliation of accessibility measures with the existing user benefits approach. This review has addressed evidence to date on wellbeing impacts of accessibility, and discussed how wellbeing evidence could potentially enhance the treatment of accessibility impacts in TAG (see Section 5).

[75] TAG Unit A1.3, and see Eliasson (2020)
[76] e.g. Handy (2020)

Current TAG modelling and applicability of SWB

TAG distinguishes between standard transport models (Figure 8 below, from TAG Unit M1) whose scope is limited to the transport sector, and supplementary economic models (SEMs) whose scope extends into the wider economy as well as the transport sector. SEMs include 'land-use and transport interaction models' (LUTI) and 'spatial computable general equilibrium models' (SCGE), among other types[77]. SEMs typically do predict some transport outcomes, although they may use less spatial and temporal detail - for example about transport supply conditions and congestion/crowding.

The link between modelling and appraisal is actually quite varied across different impacts. In some cases, there are software tools that take the output of a transport model and post-process it, in order to provide further impact information needed for appraisal. For example, in the case of accidents, the post-processing is typically done by 'COBALT' which takes network flows from the transport model, combines them with a detailed network specification and data on accident rates and severities per infrastructure type, and produces forecasts of accidents and casualties over the appraisal period[78]. COBALT also values the changes in accidents and casualties and produces a PVB (Present Vale of Benefits), so it spans both the modelling and the appraisal functions.

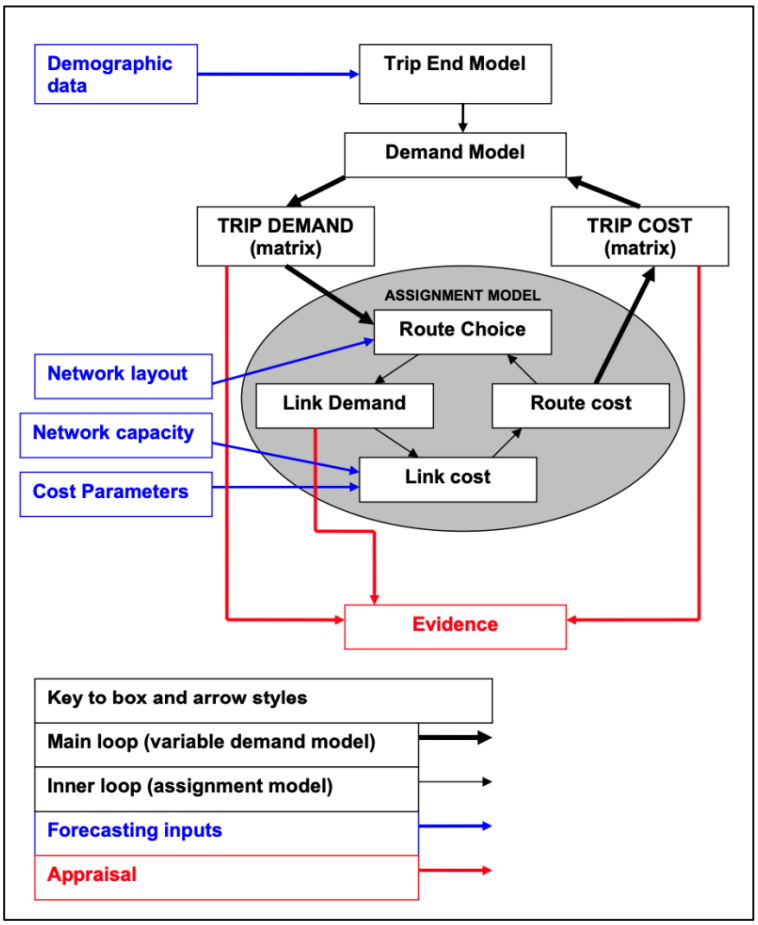

Figure 8: The standard transport model structure

[77] DfT (2019), TAG Unit M5.3
[78] DfT (2024), COBALT v2.6 User Manual https://www.tagsoftware.co.uk/COBALT

There are two main reasons why DfT may in future want to use SWB evidence in modelling:

- Validation and segmentation of values. This report has at various junctures highlighted the difficult question of whether SWB should be seen as a proxy for utility or as something different. The answer to this question has obvious implications for the practice of employing SWB to 'validate' or 'corroborate' existing utility-based values. With that qualification, we found in Sections 5&6 that SWB evidence has the potential to provide validation (in some sense) and help with segmentation for behavioural values such as the VTTS (value of travel time savings) and related values such as crowding and public transport convenience multipliers. If used in this way, SWB evidence could inform model-building very much along the same lines as existing SP- and RP-based valuation evidence has done - and probably in a complementary role, rather than replacing the existing evidence. A caveat is the assumption, necessary in interpreting the results of Krekel and McKerron (2023), for example, that choices will be motivated by the marginal values inferred from SWB data - which is a form of cardinal utility data rather than choice data. Box 2 explores this issue further.

Box 2: Under what circumstances may individual choices and behaviour diverge from individual or social welfare maximising choices?

Modelling is explicitly used to forecast outcomes, based on expected behaviour. There are well-documented reasons to believe individual choices and behaviour may diverge from choices which would maximise individual welfare or social welfare.

Individual welfare

Behavioural economics (e.g. Kahneman and Tversky, 1979; Thaler, 1992) shows that people suffer from:

- status quo bias - confronted with choices between the status quo and some other hypothetical scenario, people often exhibit a tendency to favour the status quo, even if the alternative would be better for them if it occurred - hypothetical choice methods such as SP face the challenge of putting the respondent 'into' the alternative scenario enough to obtain a meaningful assessment of the welfare gain;

- loss aversion - people respond particularly strongly to any choice in which they would lose out, e.g. a choice question where they are asked about money compensation for a deterioration in their travel experience or their environment - loss aversion can lead to estimates of willingness-to-accept (WTA) for a deterioration being many times larger than willingness-to-pay (WTP) for an equally-sized improvement (e.g. Horowitz and McConnell, 2002; T*un*çel and Hammitt, 2014);

- people's difficulty accurately perceiving risks, the time inconsistency of their preferences, and issues around myopia (short-sightedness in decision-making) are also problems that can drive a wedge between a rational 'utility maximising' prediction of behaviour and how people actually behave.

Social welfare

There are additional reasons why individual behaviour may not act towards social welfare maximisation. In particular:

- externalities to the environment - impacts such as traffic noise, air pollution and climate change are external (almost entirely) to the person deciding to undertake an activity or trip. Whether or not they are included in the individual's own welfare function (utility function) depends on the degree of altruism with which they are approaching the decision.

- externalities to other transport users - impacts such as severance, accidents and congestion are substantially external to the individual: in economic terms the marginal social cost is greater than the marginal private cost. DfT's Marginal External Cost methodology addresses many of these impacts, but is applied in appraisal, not in modelling, because the effects are assumed to occur to others, not the person making the decision about their transport behaviour.

- comparison effects - in the economics and wellbeing literature, it is recognised that people's behaviour is sometimes driven by comparisons with other people, in other words a desire to maintain or increase status relative to others (Layard *et al*, 2009; Zizzo and Oswald, 2000; Rayo and Becker, 1997). If this kind of competitive, status-seeking behaviour occurs in transport, then some people may succeed in maximising their own utility at a cost to others. Examples might include heavier and larger vehicles (and their consequences for accident outcomes, parking, road damage, etc). In wellbeing economics, the gradient of the wellbeing-income function is affected by the inclusion/exclusion of comparison effects - people appear to gain some utility from increasing their income relative to others, over and above the effect of an income gain to all people - of course this can only be zero-sum across all people, but it may lead to individuals seeking higher incomes to a greater extent than the social welfare increase would justify.

- inequality aversion - people may be averse to inequality in society (e.g. Carlsson et al, 2005). If so, then people may actually prefer policy interventions that reduce inequality - even if there is no way of expressing such preferences through choice experiments about travel behaviour, or other individual consumer choice contexts.

This substantial set of reasons for divergences between individual behaviour (or choices) and social welfare, gives us a basis for careful thought about when it is/is not appropriate to use WTP/WTA or choice-based values in appraisal, how we might design hypothetical choice experiments to avoid and address these problems, and indeed why SWB-based values may differ from individual choice-based values (e.g. Mouter et al., 2020).

- Modelling linkages between transport interventions and wellbeing outcomes. At present, there is almost no direct use of relationships between modelled variables and life satisfaction. (Among SWB metrics, life satisfaction is identified by the Green

Book Supplementary Guidance as the preferred one for CBA (see Section 4 above), although the Green Book still prefers market prices and RP). The only exception to this in TAG is the social discount rate (SDR), where life satisfaction evidence provides the basis of the η term in equation (2), and hence a large part of the 3.5%[79] discount rate for marketed impacts including changes in income and other money costs and benefits. In future it is conceivable that direct linkages between modelled variables and life satisfaction will be judged robust and included in TAG. For example, the noise values derived by Scott et al. (2020) offer the potential for a direct link from noise exposure to an effect on life satisfaction. Noise exposure is typically modelled as a separate step from the transport model[80], and the wellbeing research in this case provides the ability to model with one further step the outcome of greatest interest: the total impact on wellbeing. Clark et al (2020) have attempted to find a relationship between commute time and life satisfaction, and although this did not produce a significant result in their fixed effects regressions (focusing on within-individual changes in SWB), it is possible that with a change of research strategy a relationship could be estimated here too[81]. Moreover, the relationship between income and wellbeing (Section 5 above) is directly relevant to any model with household incomes as a variable (such as an SCGE model) when being used for welfare appraisal. The same link could be drawn for money impacts even in a standard transport model, although difficulties identifying the final incidence of transport costs and benefits is an ongoing barrier to implementing this.

Potential roles for SWB in appraisal

Having discussed the role of SWB in modelling, it is clear that SWB also fulfils at least these two potential roles in appraisal:

- As noted in relation to modelling, validation and segmentation (or enriching) of the set of appraisal values already available in TAG are two potential motivations for DfT to invest more in wellbeing-based evidence. In relation to VTTS this is more likely to employ happiness data, while for a range of other impacts (noise, air quality, option & non-use values, etc) it is more likely to use life satisfaction data. In appraisal, the caveat about happiness data not being choice data does not seem so powerful - happiness having its own justification for inclusion (as a form of wellbeing) in appraisal. In many of these impacts, the SWB evidence is in life satisfaction terms anyway. Appraisal values will be in the market prices unit of account, whereas

[79] stepping down to 3.0% after 30 years (HM Treasury, 2022)

[80] DfT (2023) TAG Unit A3 Environmental Impact Appraisal

[81] Clark et al's (2020) finding that the relationship between commute time and life satisfaction is insignificant accords with some of the wider literature, including Dickerson et al (2014). They find highly significant relationships with domain satisfactions for Job Satisfaction and Leisure Time satisfaction (>99%), and they speculate about why this fails to feed through into a measurable impact on Life Satisfaction. They state: "Workers in England appear to be successful in balancing the negative aspects of commuting against the wider benefits, e.g. access to employment, earnings and housing". This echoes Dickerson et al (2014) who state: "According to microeconomic theory, individuals would not choose to have a longer commute unless they were compensated for it in some way, either in the form of improved job characteristics (including pay) or better housing prospects (Stutzer and Frey, 2008). Even if commuting in itself is detrimental to well-being we would therefore not expect individuals with longer commutes to report lower levels of life satisfaction". It may therefore be necessary for future research to try to unpack these positive and negative effects.

modelling values will depend on whether the agent is in the household sector (e.g. leisure trips) or the production sector (e.g. business travel).

- SWB evidence also provides a direct link to the outcome indicator of interest - a form of welfare metric[82]. As above, this could be relevant to noise, air quality, commute time, and many other impacts.

In addition, SWB evidence offers a new approach to the scope of the impact. For impacts such as noise and air quality where the IPA is currently used for valuation in appraisal, SWB offers the potential to value them in terms of their total impact on the person, which could be helpful in expanding the scope of the valuation where there are concerns it may be too narrow, or narrowing it where there are concerns about double counting in the existing method.

Finally, areas of TAG particularly worth highlighting in relation to the potential use of life-satisfaction-based appraisal values are Wider Impacts and Distributional Impacts analysis. In the Wider Impacts appraisal[83], there appears to be potential to apply the SWB-based evidence (in Section 5) to income and employment impacts. In relation to DI analysis, we currently have distributional weights for income effects and possibly other money (dis)benefits to households, subject to identifying the incidence of the (dis)benefits, based on the income-wellbeing relationship from Layard et al (2008) incorporated in HM Treasury (2022). The SWB evidence suggests that other forms of segmentation in the values may be useful, in order to reflect the true benefits to different social groups.

[82] We will come back later to consider the main limitations of life satisfaction as a welfare metric.
[83] TAG Units A2

8. Scope for additionality

This section addresses the key issues in additionality and double counting, and brings out specific examples from the review.

Economy impacts

TAG appraisals include not only benefits to transport users, but also benefits in the wider economy which contribute to welfare change. For example, in the appraisal of the Elizabeth Line, very substantial wider impacts were estimated in the form of: agglomeration benefits (increased productivity); increased tax revenues from people moving to more productive jobs or entering the labour force; and benefits from reduced transport costs under imperfect competition. Table 15 summarises the results and puts these benefits into the context of the appraisal as a whole.

Impact	£million, Present Values (at 2002 prices and values)	
	Costs	Benefits
Costs		
Capital costs	10,626	
Maintenance costs	1,606	
Operating costs	1,670	
TOTAL Costs	13,902	
Revenues		
Net rail revenue impact (deduct from Costs)	6,149	
Transport user benefits		
Commuting/leisure time savings		7,985
Commuting/leisure decrowding/ambience		2,889
Commuting/leisure other benefits		355
Business travel time savings		4,847
Business other user benefits		17
TOTAL Transport user benefits		16,093
Wider economy - welfare benefits		
Agglomeration benefits		3,094
Tax revenue (move to more productive jobs)		3,232
Tax revenue (labour force participation)		349
Imperfect competition		486
TOTAL Wider economy - welfare benefits		7,161
Other benefits		
Indirect tax revenue (loss)		-1,207
Summary		
Net Present Value (NPV)	14,294	
Benefit:Cost Ratio (BCR)	2.84	

Table 15: Elizabeth Line appraisal showing additional welfare impacts in the wider economy

In this case, the additional welfare benefits measured in the wider economy made up 32% of the Present Value of Benefits, and 50% of the project's overall Net Present Value (NPV)[84]. These wider impacts have been defined and formulated specifically to avoid double-counting with the transport sector benefits - these are externalities arising from the fact that the wider economy does not operate under conditions of perfect competition. Instead there is taxation, there are agglomeration economics and transport-using sectors are imperfectly competitive[85].

In relation to economy impacts, this review has so far highlighted two potential additions to the current TAG welfare appraisal. The first is **the wellbeing impact of being in employment as opposed to unemployment**, taking the impact of income as given and already included (see Figure 9). This was discussed in Section 5. Implementation would require estimates of the number of people moving between unemployment and employment as a result of the intervention. TAG Unit A2.3 sets out the Department's approach to changes in unemployment, in the context of HM Treasury Green Book guidance. Local economies may temporarily operate below full employment due to exceptional circumstances - e.g. the closure or shrinkage of a dominant major employer or industry. In order to assess the impact of the transport intervention:

> "the scheme promoter needs to provide the following information in the Economic Narrative: (1) present context specific evidence which demonstrates the local economy is operating below full employment; (2) determine the length of time before the economy would be expected to return naturally to full employment; (3) justify why the particular transport investment is expected to reduce unemployment; (4) determine the persistence of the new jobs; (5) explain how these impacts are to be quantified and valued".

It would be preferable to develop any analysis of this as an extension to the TAG Unit A2.3/WITA framework, integrating labour supply impacts and any change in unemployment, rather than something separate (extending equations 1-6 in the TAG Unit).

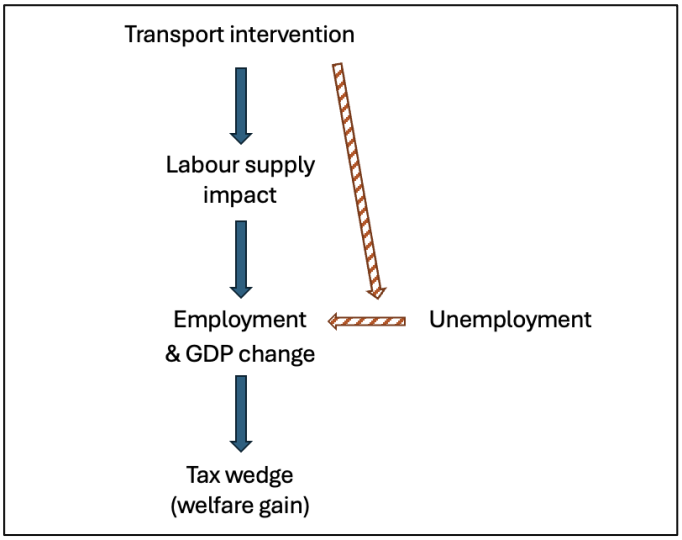

Figure 9: Localised changes in unemployment, relative to TAG employment effects

[84] Table 11 is based on the reported 2005 appraisal of Crossrail/Elizabeth Line (Crossrail Ltd, 2005 https://learninglegacy.crossrail.co.uk/wp-content/uploads/2023/04/Economic-Appraisal-of-Crossrail-2005.pdf), but allocating the 'Indirect tax revenue' impact to the Present Value of Benefits in line with current practice.

[85] DfT (2019) TAG Unit A2.1; Venables et al (2014)

The applicability of this may be limited, however: the current highest level of unemployment in a local authority area is 7.3%[86], while the mean is 3.6%[87]; and the ability of transport interventions to enable people to move from unemployment to employment is unclear - although there is evidence focusing on the link between transport disadvantage and unemployment (e.g. Fransen et al, 2019)[88].

Secondly, and perhaps more widely applicable, is **the impact of income changes on wellbeing**, particularly in the context of inclusive growth or levelling-up interventions. In this case, the potential addition to current TAG welfare impacts comes from the differential wellbeing impact on high and low income individuals, applied to:

- agglomeration effects, increasing productivity and output (TAG Unit A2.4);
- labour supply effects, leading to a social welfare gain from the tax wedge (TAG Unit A2.3) - as in Figure 9.

For example, take a place-based intervention[89] which raises local GDP and employment, in an area with an income profile below the national average. Not only is there a welfare change due to any agglomeration effects and the tax wedge effect from employment, there is also potentially a further welfare gain due to the distributional effect: the beneficiaries are starting below the median income and therefore - according to the income-wellbeing relationship set out in Section 5 and the Green Book distributional weighting guidance (Annex 3[90]) - there is in an additional welfare gain. Theoretically this would apply even if the intervention caused pure displacement, however such an intervention would be unlikely to perform well against interventions that *did* offer overall GDP or employment gains, as well as an additional distributional benefit.

It is worth noting that national policies as well as place-based policies could benefit from the inclusion of this impact. Take a national policy which reduces bus fares for instance: outside London, people in the lowest income quintile use bus 2.5 times more frequently than the middle quintile[91]. While reduced bus fares do not impact on income, for a regular bus user they impact on the household budget constraint, freeing-up income for other expenditure. Valuation of this, using the available SWB-based value, could be a useful complement to the method currently set out for Personal Affordability in TAG Unit A4.2, allowing the income-related part of Distributional Impacts to be included in the AMCB[92] table, and the NPV and BCR.

[86] in Birmingham
[87] ONS (2024) Labour market in the regions of the UK, Jan 2024 https://www.ons.gov.uk/employmentandlabourmarket/peopleinwork/employmentandemployeetypes/datasets/li01regionallabourmarketlocalindicatorsforcountieslocalandunitaryauthorities
[88] It is also necessary to consider that a part of the welfare gain may be captured by the user benefits in the transport market. Accounting for this may be necessary to avoid any double counting in the CBA as a whole.
[89] see TAG Unit A4.3
[90] HM Treasury (2022)
[91] DfT (2024) Table NTS0705 https://assets.publishing.service.gov.uk/media/64e8b06c691aa3000da56e16/nts0705.ods
[92] Analysis of Monetised Benefits and Costs

Broadening the scope & recognising the full value

Another type of additionality is where SWB evidence could allow the scope of valuation in TAG to be broadened. Emerging from this review are a few clear or potential examples of this. Most of these would require further research - the necessary empirical work has not yet been done.

- **Reliability.** Although frequently given as one of the most pressing concerns of transport users - both passenger and freight - reliability is in the 2nd tier, '*Evolving* monetised impacts', rather than the 1st tier, 'Established monetised impacts', in the DfT Value for Money Framework (DfT, 2017). It is therefore included in the less robust 'Adjusted BCR', but is not part of the more robust 'Initial BCR'. This is a consequence of the methodological challenges with reliability - mainly in modelling reliability impacts of interventions, rather than any challenges of valuing it. Indeed, robust valuations of reliability were estimated for all surface modes as part of the most recent UK national VTTS and Value of Travel Time Reliability (VTTR) study undertaken by Arup et al. (2015). That said, a complication which arose in that study, which the Department has since been working through, is the challenge of dissecting VTTR from congested values of travel time (CVTT). In the context of the 2015 study, VTTR sought to capture the inherent uncertainty of travel time, whilst CVTT sought to capture the comfort of driving in different traffic conditions. But it is undeniably the case that congestion could lead to delay, raising the question of whether, in the context of appraisal, the two concepts can really be treated as independent and thus additive. What would seem clear is that both reliability and congestion (as well as crowding, the PT equivalent of congestion) have a significant detrimental impact on the well-being of travellers.

- A happiness-based SWB approach could be useful to value this, and Krekel and McKerron (2023) offers some progress in this direction. Another body of work potentially of relevance, especially for rail travel, is that associated with the National Rail Passenger Survey (NRPS). NRPS is a bi-annual survey of passenger satisfaction conducted by Transport Focus, which has been built into franchising agreements and provides a passenger-centric perspective on the comparative performance of franchised TOCs. The survey is administered by intercepting passengers on trains or at stations in the course of making journeys. Passengers are asked multiple questions concerning their journeys, and in particular their satisfaction with different aspects of the journey, ranging from station facilities and ticketing to journey times and in-vehicle experience. For each such question, passengers are asked to report their satisfaction on essentially a 5-point scale, where 5 = ‘very satisfied’; 4 = ‘fairly satisfied’, 3 = ‘neither satisfied nor dissatisfied’; 2 = ‘fairly dissatisfied’; 1 = ‘very dissatisfied’ (where a sixth point 0 = ‘don’t know/no opinion’).

- In a recent study for Network Rail (Batley et al., 2023), analysis was undertaken to explore and better understand different thresholds of satisfaction. More specifically, statistical models were developed to explore the existence of a systematic and quantifiable relationship between passenger rail performance and passenger satisfaction, whilst controlling for other factors which could influence passenger satisfaction. These models were developed at various levels of aggregation, employing data at the level of an individual passenger (capturing incidental delay), at the level of a station-to-station journey (capturing average delay), and also segmenting by different journey purposes, operators and spatial corridors. The key

output from the study was a recommended model at the level of the station-to-station journey, which can be applied in a forecasting context to determine the level of passenger satisfaction associated with a given level of average delay, and how satisfaction would change if average delay improved or deteriorated further.

- Related work recently undertaken by ITS in the context of ongoing PhD study has been to explore the scope to derive explicit valuations of passenger rail delay from the NRPS data. In essence, the approach followed was to reinterpret the NRPS 'satisfaction' scale as a 'utility' scale, and model the level of utility as a function of delay at the origin and destination and scheduled journey time, whilst controlling for satisfaction with other aspects of the journey. The outcome of the analysis was the estimation of 'lateness multipliers' for different journey purposes, which bore reasonable correspondence to those estimated through conventional SP analysis and adopted in the Passenger Demand Forecasting Handbook (PDFH). Lateness multipliers represent the marginal rate of substitution between the lateness and scheduled journey time, and could be readily monetised by multiplying by VTTS.

- This sort of approach - essentially quantifying and valuing a domain satisfaction, or rather a within-domain satisfaction indicator - could be a very useful alternative way of quantifying and valuing reliability effects. In terms of Figure 6, this could move reliability valuation from a 'momentary' basis to a quarterly or annual impact on the person.

- A broader perspective still, may be to focus on the total value of having a dependable transport service. This points towards research on resilience, which attempts to model and measure how quickly and completely a system recovers from a shock - such as extreme weather events or infrastructure damage - and longer-term system performance metrics (e.g. Chen and Rose, 2018; DfT, 2014). The costs of maintaining a resilient rail service in the face of climate-related changes are addressed by Dawson et al (2016), but the social value of resilience is an important and unresolved question.

- **Townscape/urban realm.** Street functions can be broken down into two categories: movement functions - involving travel by any mode - even very short walks between buildings, for example; and place functions (e.g. Jones et al, 2007). Place functions include 'exchange' such as meetings and social interaction, outdoor eating and drinking, retail (outdoor or spill-out from indoor), resting, sitting, playing, enjoyment of parks and parklets as part of the urban realm, and the benefits of green & blue infrastructure such as street trees, canals, fountains, and other features. In theory, TAG appraisals are well attuned to measuring the user benefits of improvements in the movement function[93], but currently TAG does not attempt to capture very much of the exchange function[94] (Nellthorp, 2023). This means that for appraisals of urban realm schemes in high streets, local centres, city centres, and many other areas where streets have mixed uses, part of the benefit is omitted. How big the omission is, is an empirical question with no answer in the literature as yet. In terms of method, it seems possible to investigate these benefits using a momentary utility/happiness

[93] In practice, this ability is limited by the availability and use of very detailed models of short trips.

[94] the values of aspects of the pedestrian environment in TAG Data Book Table A4.1.7 are widely used, and are incorporated in the Active Mode Appraisal Toolkit (AMAT) - they are values per km walked through the street environment, rather than time spent in one particular street location. They cover: street lighting; kerb level; crowding; pavement evenness; information panels; benches; and directional signage.

approach such as that used by Krekel and McKerron (2023). Equally, it seems appealing to investigate this using life satisfaction data to capture the value of local place quality attributes - we discussed the value of green space in Section 5. Other, existing valuation methods also seem relevant, including hedonic pricing (as in Millard et al, 2018 or Nellthorp et al, 2019) and stated preference (as in Atkins and ITS, 2011). To address whether such effects are additional in TAG, we need to consider where does the externality arise from? In some cases, the externality may result from the absence of destination attractiveness in the transport user benefit measure (Bates, 2006), and the co-creation of benefits related to meeting friends, contacts and others - the 'exchange' role of streets and urban places. In other cases, the externality may relate to transport impacts around the home location - including impacts on urban realm and green space.

- **Journey quality**. There are also many street attributes which are not yet valued as journey quality attributes for walk and cycle movement, e.g. traffic exposure, lane/pavement width and continuity (Nellthorp, 2023). These would be amenable to an SWB (momentary, happiness) approach, but also to SP and RP methods.

- **Health impacts of active travel.** Although mortality impacts (on life expectancy) are included now in TAG appraisals for active travel interventions, morbidity impacts - on quality of life - are not (Nellthorp, 2023). SWB data, along with data on overall physical activity and health outcomes, are natural sources of evidence to support a valuation. Mediation models may be useful here to separate out the health impact pathway from the residual SWB effect. There has been some attention to this gap in Australia and New Zealand (Zapata Diomedi et al, 2018).

- **Distributional impacts**. Aside from the income weighting point, distributional impact (DI) analysis in TAG highlights how different transport users have very different experiences of the same transport system, and how it meets (or does not) their particular needs. DI analysis in TAG relates to: children and young adults; older people; gender; people with a disability; ethnicity/race; and caring responsibilities including dependent children[95]. People's wellbeing at a much more segmented level, and the ways in which the transport system impacts on it, could be addressed in relation to a whole set of impacts including: income and affordability; access to services; and a range of other environmental and social impacts.

Avoiding double counting

Finally, there is the potential to check for overlap between impacts within an impact pathway (IPA) valuation, e.g. amenity value and health impacts in noise valuation. Also to check whether the summation of use values (for transport), option values and non-use values are empirically consistent with overall measures of the value of accessibility, or whether there is evidence of double counting.

In Section 5 of this report (under 'Noise and wellbeing'), we explained why SWB evidence could help to provide a holistic valuation and clear up the remaining doubt about double counting in the Defra (2014) noise values. Unfortunately the SWB evidence to date has not

[95] TAG Unit A4.2

allowed this to be done, since it omits values for road and rail, and since there are questions about the order of magnitude of the results (see text above).

In the case of use values, option values and non-use values, we do not yet have SWB evidence on the total value of accessibility, hence the comparison cannot yet be made.

9. Areas with greatest potential in TAG

Potential use of SWB evidence in valuing transport impacts

This report has identified four principal ways in which subjective wellbeing (SWB) evidence could support and potentially enhance the valuation of impacts in transport appraisal.

1. Validation. SWB evidence has the potential to provide further validation of values in TAG - although this requires articulation of the precise relationship between SWB and utility and, depending on the answer to that question, definition of what constitutes 'validation' in this context. So far, the SWB evidence is most promising in relation to valuation of travel time changes, using momentary happiness data (Krekel and MacKerron, 2023). The values in TAG are already based on a large body of high quality SP & RP evidence, including meta-analyses. The SWB evidence requires some further unpacking, and we have recommended some additional questions for inclusion in future SWB data-gathering that would allow more exact empirical comparisons to be made (see Section 5 - Travel time and wellbeing). Pursuing this could help build confidence in the applicability of SWB data in appraisal, and test the equivalence between preference-based and SWB-based values.

In future, it seems reasonable to expect that SWB evidence will provide validation for the TAG values of other impacts, including noise, air quality, physical activity, journey quality, security, option values and the social value of bus services[96]. The SWB evidence is not, however, consistent enough or robust enough in other ways to attempt this validation yet (see Section 6). Instead, further empirical analysis using SWB data is needed, to produce estimates which match the required scope and demonstrate causality, external validity and accuracy.

2. Segmentation and distributional impacts. Proportionality is recognised as important in appraisal, and this applies to segmentation: the amount of segmentation needs to be proportionate - it is not practicable to model and appraise the impact on every conceivable segment. Nevertheless, SWB evidence has highlighted a number of ways in which values differ across the population and from context to context. In particular:

[96] The social value of bus services is part of the TAG user benefits calculation (TAG Unit A1.3 and TAG Data Book Table A1.3.16-18).

- The momentary happiness-based analysis of travel time[97] highlights additional attributes such as instantaneous travel conditions, interaction with weather and whether accompanied or not (and by whom). The app-based experience sampling method makes data gathering relatively easy, although many of these attributes may also be captured efficiently using SP experiments, and on a note of caution, it is likely that most of the larger influences on VTTS have already been captured - at least in terms of journey attributes.

- A more fruitful area, in terms of the potential impact on appraisal results, is to bring SWB evidence into the assessment of distributional impacts (DIs). TAG already assesses impacts on population segments including children, older people, people with a disability, black and minority ethnic communities, people without access to a car and people on low incomes. The SWB evidence points to specific ways in which impacts differ across segments, and offers the potential to quantify and value these differences on a wellbeing basis, including, e.g.:

    - the wellbeing impact of income changes - caused by Wider Impacts (agglomeration/productivity changes, for example) or potentially by other money impacts on households, such as transport costs and fares - differs by income group ('distributional weights', HM Treasury, 2022);

    - the wellbeing impact of accessibility is materially different across people with mobility impairments, those living in rural areas, over 50s and people with no car available (Chatterjee at al., 2019).

- Improving the analysis and evidence base for these impacts would not only strengthen the distributional impacts assessment, but contribute to the NPV ('public value') and BCR ('value for money') of transport interventions.

3. Broadening. We have identified a number of areas where SWB evidence has the potential to broaden the scope of the current TAG values. These include a number of place-based impacts (e.g. regeneration, townscape/urban realm and severance) - this would require empirical research before any application could be made in TAG, and would likely use life satisfaction data. We also identify the potential to use momentary happiness data to expand the scope of journey quality valuation, for example.

4. Avoiding double counting. Although care has been taken in developing TAG to avoid double-counting, we have identified two areas where SWB evidence may be helpful in avoiding double-counting in future. One of these is to cross-check/validate the values of transport noise and air quality arising from impact pathway (IPA) valuation, where there is some residual risk of double counting between different branches of the impact pathway - e.g. between amenity and health impacts of transport noise. The other is to ensure that the various components of the total value of transport provision - including user benefits, option and non-use values, and social values of bus service provision - are in line with the total wellbeing impact measured using SWB methods.

[97] Krekel and MacKerron (2023)

Overview of potential for TAG impacts

Table 16 summarises the potential for use of SWB evidence to strengthen TAG.

#		Impact	Components	SWB values: Relevant & Robust	SWB values: Emerging	SWB data: Potential to enhance valuation: Validation	Scope (total value)	Enriching (segmentation)	Issue - Relevance
1	Economy	Business users & transport providers	User benefits: travel time						
			User benefits: vehicle operating costs						
			User benefits: user charges						
			During construction and maintenance						
			Providers: costs/revenues						
2		Reliability impact on Business users							
3		Regeneration							
4		Wider Impacts							
5	Environmental	Noise							
6		Air Quality							
7		Greenhouse gases							
8		Landscape							
9		Townscape							
10		Historic Environment							
11		Biodiversity							
12		Water Environment							
13	Social	Commuting and Other users	User benefits: travel time						
			User benefits: vehicle operating costs						
			User benefits: user charges						
			During construction and maintenance						
14		Reliability impact on Commuting and Other users							
15		Physical activity							
16		Journey quality							
17		Accidents							
18		Security							
19		Access to services							
20		Affordability							
21		Severance							
22		Option and non-use values							
23	Public Accounts	Cost to Broad Transport Budget							
24		Indirect Tax Revenues							
Other parameters used in TAG:									
		Elasticity of the MU of income w.r.t. income							
		Social Time Preference Rate (STPR)							
		Distributional Weights							
						Key:	Highest potential		
							Some potential		
							Only relevant w.r.t. impact on user (employee)		

Table 16: TAG impacts and the potential to enhance valuation using SWB evidence

The key points shown in the table are:

- Wellbeing is of limited relevance to the Business Users and Transport Providers part of the TAG Appraisal Summary Table. This is focused on businesses rather than households, and the impacts on businesses are primarily financial, rather than welfare impacts. There are some links to wellbeing, however, in particular:
    - the employee's component of the value of business travel time savings and other user benefit components that are perceived differently by the traveller (this may include reliability and disruption during construction/maintenance)[98]; and
    - workplace wellbeing - which is of course an impact on employees but can also rebound on employers in terms of absenteeism/presenteeism and productivity[99].

[98] see Section 5.

[99] e.g. RSSB Health and Wellbeing Index (HWI) for the rail industry workforce (https://www.rssb.co.uk/research-catalogue/CatalogueItem/T1239)

- There is evidence on the wellbeing impact of disruption during construction, which could be considered for development and generalisation, with a view to including in TAG.

- There is potential to include SWB evidence on the value of employment versus unemployment, and to weight income gains in line with SWB (life satisfaction) evidence (Wider Impacts).

- Place-based impacts in general have the potential for SWB (life satisfaction)-based evidence gathering, broadening the scope of valuation in TAG. Relevant impacts include: Regeneration; Townscape/Urban Realm; Landscape; Historic Environment; Biodiversity; Water Environment; Access to Services; and Option & Non-Use Values of transport access.

- Biodiversity and Water Environment are subject to ecosystems services approaches, and research is underway to strengthen valuation using wellbeing data.

- In general, where current values were derived using SP and RP methods, there is potential for validation and enriching using SWB evidence. Value of travel time savings (non-work) was identified as an example.

- By enriching, we mean analysis of how different transport users have very different experiences of the same transport system - by age, gender, and other characteristics. This applies almost across the board to the TAG impacts.

- Noise is on the cusp of SWB (life satisfaction)-based valuation, however the latest SWB-based research only addresses aircraft noise. An extension of the work to roads and rail (including urban street-running rail) would be valuable at this time.

- There is considerable potential for reliability valuation using SWB methods - in the broadest sense, and here we think journey satisfaction may be an appropriate level for data gathering, possibly alongside life satisfaction evidence over the longer-term (and all trips). These could allow researchers to address resilience as well as reliability as currently defined in TAG, and to compare the journey level and overall results.

- Physical activity benefits currently lack a quality of life dimension, and SWB data would be a natural source of evidence.

- Affordability naturally falls into the assessment of income-related weighting on money benefits and disbenefits.

Most promising directions for appraisal development and empirical research

A short list of the most promising directions for appraisal development and research emerging from this report is given below, **not yet ordered in terms of their potential impact on appraisal outcomes.**

1.	Validation of VTTS using SWB (happiness) data - some re-analysis of existing Mappiness data, mainly gathering new data/survey design.
2.	Enriching/segmentation of VTTS using SWB (happiness) data - more elements of generalised cost, and/or more user types, and more different travel conditions.
3.	Enriching valuation of transport provision by analysis of different users' experiences of the system - by age, gender, disability, caring and other characteristics, with different mobility needs and preferences (relating to User benefits and Accessibility).
4.	SWB (life satisfaction)-based valuation of noise.
5.	SWB (life satisfaction)-based valuation of air quality - UK based research.
6.	Weight income gains in line with SWB (life satisfaction) evidence (Wider Impacts).
7.	SWB value of shift from unemployment to employment.
8.	Quality of life dimension of physical activity benefits.
9.	Place-based impacts using SWB (life satisfaction): Regeneration; Townscape/Urban Realm; Landscape; Historic Environment; Biodiversity; Water Environment; Access to Services; and Option & Non-Use Values of transport access.
10.	Reliability valuation using SWB methods - journey satisfaction and life satisfaction evidence.
11.	Affordability and income weighting.
12.	SWB valuation of disruption during construction.
13.	Biodiversity and Water Environment - for the future.

Table 17: Most promising directions for appraisal development and empirical research

10. Potential for Empirical Work

Areas of opportunity for empirical work

Following on from the previous section, Table 18 below documents the areas we consider most promising for empirical work, gives additional detail on the research activities which could be practicable in the short and long term, and notes whether these activities would be focussed upon happiness (H) or life satisfaction (LS) data.

Specific areas of opportunity for empirical work include:

- VTTS and multipliers – various work to corroborate/validate conventional SP values; further consideration of theory and re-allocation of time at the margin
- Accidents, AQ, noise, physical activity – potential work on health-related impacts
- Reliability – using multiple forms of data, including satisfaction, to strengthen the robustness of values and forecasts
- Disruption during construction and maintenance – scope for mixed methods approach (potentially in combination with Reliability)
- Place based impacts including Townscape and Urban Realm – for the reason that SWB data for residents potentially captures location-based changes in welfare

More generally, there is the opportunity for further empirical work to better understand variations in impacts across different travellers, journey purpose/mode combinations and locations, through:

- Segmentation and distribution – evidence of differential impacts by social groups, not limited to income but including income; this requires better understanding of the income coefficient in SWB and its reconciliation with the income coefficient from WTP.

There is also a need to investigate the apparent discrepancies which were found during this study between the WELLBY values implied by different methods. The Green Book recommendation is £13,000 per WELLBY at 2019 prices, with a range of £10,000 to £16,000. Frijters and Krekel (2021) recommend £9,000 in 2015 which is approximately

equal to £10,000 in 2019 prices - so within the same range. The study by Krekel and McKerron (2023), however, produces a value per WELLB-Hour of £20 which raises the question of how this should be scaled-up. Should we expect it to be scaled up linearly over the whole year (8,760 hours), in which case the implied WELLBY value is £175,000? Or perhaps only working time (say 1,760 hours), giving £35,000? Both are higher than the Green Book range, the former roughly 11 times higher than the top of the Green Book range.

Another apparent discrepancy is between the income coefficients arising from panel data studies such as Layard et al (2008) which we described earlier as "robust", and the income coefficients arising from discrete choice models - particularly that by Fujiwara and Dass (2021), which is used in the derivation of the £16,000 WELLBY value. The former study method appears to produce a coefficient on ln(income) of around 0.2-0.4, while the latter produces a coefficient of 1.96 (after both are expressed using the 0..10 scale for life satisfaction).

Potential research activities relating to impacts

Impact(s)	**Potential Work**	**Happiness (H) / LS**
VTTS and multipliers	Re-analysis of the Mappiness dataset to try to isolate in-vehicle time and walking time, and influence of weather & accompanied, using existing variables and interaction terms. (Short term option). Gather new data including mode and trip stage questions, plus travel conditions - all missing from Mappiness dataset. Use to explore further validation and segmentation of values (Long term option).	H
	Re-investigate commuting and life satisfaction – develop a dataset focusing on transport interventions, exogenous changes (new stations & services, urban interventions (streets), infrastructure changes, etc); include housing quality and costs (confounders). Use secondary data (UK) (short term option). Boost surveys/tailored data gathering. "Sample size could be upwards of 1% of the population ...and in absolute terms a sample of 1,000-2,000 would be desirable" for a localised intervention. (Long term option).	LS
Noise	Multi-modal noise valuation study for an area. Analogous to Bateman, Day & Lake (2004) but including aviation noise (day and nighttime). BDL used 10,848 property transactions (HP analysis). Aim to obtain consistent and complete value set. + Carry out rapid review of noise valuation studies (internationally) to benchmark SWB findings against latest HP, SP, CVM & IPA evidence.	LS*
AQ	Use the daily fluctuation data (H) and trends (LS) in air quality to build SWB models for the UK. Consider using Luechinger's joint SWB & HP method to capture both health benefits and increased housing costs in areas with cleaner air. Include NOx and PMs, and interactions – to address double-counting/additionality. + Benchmarking.	H,LS*
Accidents, AQ, Noise, Physical Activity	Health impacts. Explore (i) SWB-based instead of SP-based values for QALY; and (ii) SWB-based values for quality of life (morbidity) benefits of physical activity – currently omitted from the TAG values and AMAT. Limitation is the quality of data on physical activity (Sport England Active Lives Survey). Primary data gathering is recommended.	LS
Reliability	Make further use of passenger satisfaction data and/or instantaneous happiness data to validate/strengthen the values for reliability in TAG, and to inform models of rail reliability.	H LS

	Explore resilience measures & longer-term system performance metrics to investigate the social value of resilience in transport networks.	
Disruption during construction & maintenance	National UK study on values of disruption, including: LS-based analysis of localised, place-based road disruption near to home (building on Fujiwara et al, 2018, Anglian Water area) In-trip disruption: H-based analysis of experience on rail & PT. May need to use SP or other satisfaction data to address inter-urban roads (feasibility of mobile app).	LS H
Place based impacts (incl. regeneration, townscape, severance)	Both in-trip (Happiness-based) and overall (LS based) measurements possible. It may be worth using both and attempting to reconcile, to increase confidence in results. Benchmark against SP evidence (for townscape & severance). Focus data gathering on areas with regeneration/urban realm schemes/severance changes during the period, plus control areas. This could also be investigated using SP/CVM. Would require visualisation/simulation.	H, LS

Table 18: Potential areas for empirical research and specific activities

Commissioning model

We note that, whilst some of the above activities would fall directly within DfT's remit (e.g. VTTS), there are other activities which may lend themselves to partnership working across other government departments or public bodies, for instance:

- Transport noise and AQ (with Defra, JAQU)
- Physical activity (with ATE, DHSC, DCMS)
- Health/QALYs (DHSC)
- Journey quality, reliability and disruption (with NH, NR)
- Place-based impacts (with MHCLG).)

11. Recommendations

Recommendations for DfT

Based on the conceptual, evidential, and practical arguments covered in this report, our headline recommendation is that:

R1: DfT should continue to invest in the development of SWB methods, with a view to their adoption in targeted areas of TAG where they bring new insights, and the requisite levels of assurance are demonstrably met.

The report has identified four general areas where SWB could potentially add value to TAG. On this basis:

R2: A programme of development work should be commissioned around the specific areas of a) validation; b) segmentation and distributional impacts; c) broadening of TAG values and d) double-counting, to explore practicalities and build assurance.

R3: Areas a), b) and d) would be best developed through conceptual and case study work based on impacts which are well established within TAG - a good candidate would be VTTS, possibly extending to also cover reliability and congestion.

If successful, conceptual work will help to demonstrate how traditional and SWB-based values are comparable, and case study work will help to demonstrate proof of concept for the implementation of SWB within TAG.

R4: Area c) would be best developed through cross-departmental or cross-agency partnership, possibly involving HMT.

R5: As an input to R4, DfT should review the areas of opportunity identified in Section 10 of this report and determine their priorities from the perspectives of both policy and analysis.

Notwithstanding R1, this report has highlighted various technical areas which are unresolved and could impede the adoption of SWB within TAG. Examples include the interpretation of the income coefficient, the availability of nationally representative SWB data, and the ability to model and forecast SWB.

R6: DfT should undertake a small piece of work to document outstanding technical challenges in relation to SWB and formulate an action plan towards their resolution, where appropriate working in partnership with other relevant departments and agencies.

Recommendations for analysts and scheme promoters

R7: In advance of the development work recommended in R2, there are opportunities for the implementation of SWB in business case work, but this should be limited to the following areas:

a) validation of impacts which are already covered in TAG;

b) sensitivity testing of impacts which are already covered in TAG;

c) distributional and/or segmentation analysis;

d) quantification and/or articulation of impacts which inform the narrative of the strategic case - even if such impacts are not (presently) admissible to the economic case.

References

Alcock, I., White, M.P., Wheeler, B.W., Fleming, L.E. and Depledge, M.H. (2014). Longitudinal effects on mental health of moving to greener and less green urban areas. *Environmental Science and Technology*, 48, 1247-1255.

Arrow, K., Solow, R. Portney, P.R., Leamer, E.E., Radner, R. and Schuman, H. (1993). Contingent Valuation Methodology Report: Report of the NOAA Panel on Contingent Valuation. *Federal Register,* 58, 4602–4614.

Arup, ITS Leeds, Accent (2015). *Provision of market research for value of time savings and reliability*. Phase 2 report to the Department for Transport. https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/470231/vtts-phase-2-report-issue-august-2015.pdf

Atkins and ITS (2011). *Valuation of Townscapes and Pedestrianisation*, Final Report to DfT. London: Atkins. https://assets.publishing.service.gov.uk/media/5a78f665e5274a2acd18b250/pedestrianisation-townscape-research-report.pdf

Batley, R. (2008). On Ordinal Utility, Cardinal Utility and Random Utility. *Theory and Decision*, 64, 37–63. https://doi.org/10.1007/s11238-007-9046-2

Batley, R.P. et al. (2017). New appraisal values of travel time saving and reliability in Great Britain. *Transportation*, 46, 583-621. https://link.springer.com/article/10.1007/s11116-017-9798-7

Batley, R., Rossa, K. & Smith, A. (2023). Passengers' acceptability of delays. Report to Network Rail, commercial in confidence.

BEIS (2021). *Valuation of greenhouse gas emissions: for policy appraisal and evaluation*. https://www.gov.uk/government/publications/valuing-greenhouse-gas-emissions-in-policy-appraisal/valuation-of-greenhouse-gas-emissions-for-policy-appraisal-and-evaluation

Bertram, C. and Rehdanz, K. (2015). The role of urban green space for human well-being. *Ecological Economics*, 120, 139-152.

Bickerstaff, K. and Walker, G. (2001). Public understandings of air pollution: the 'localisation' of environmental risk. *Global Environmental Change,* 11, 133–145.

Bondemark, A., Kopsch, F. and Johansson, E. (2021). Accessibility and uncertainty: An empirical analysis of option value in transport. *Journal of Transport and Land Use,* 14(1), 463–477. https://www.jstor.org/stable/48646194

Bristow, A.L., Hopkinson, P.G., Nash, C.A. and Wardman, M.R. (1991). *Evaluation of the use and non-use benefits of public transport. Report No. 2. Application of the method.* ITS Working Paper 310. Leeds: ITS. https://eprints.whiterose.ac.uk/2248/

Carlsson, F., Daruvala, D. and Johansson-Stenman, O. (2005). Are people inequality-averse, or just risk-averse?. *Economica*, 72(287), 375-396.

Carrus, G., Scopelliti, M., Lafortezza, R., Colangelo, G., Ferrini, F., Salbitano, F., Agrimi, M., Portoghesi, L., Semenzato, P. and Sanesi, G. (2015). Go greener, feel better? The positive effects of biodiversity on the well-being of individuals visiting urban and peri-urban green areas. *Landscape and Urban Planning*, 134, pp.221-228.

Carson, R.T. and Groves, T. (2007). Incentive and informational properties of preference questions, *Environmental and resource economics*, 37, 181-210.

Chatterjee, K., Clark, B. Nguyen, A., Wishart, R., Gallop, K., Smith, N. and Tipping, S. (2019). *Access to Transport and Life Opportunities.* London: Department for Transport. https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/831766/access_to_transport_report.pdf

Chen, Z. and Rose, A. (2018). Economic resilience to transportation failure: a computable general equilibrium analysis, *Transportation*, 45(4), 1009-1027. https://doi.org/10.1007/s11116-017-9819-6

Cheng, Y.H. (2010). Exploring passenger anxiety associated with train travel. *Transportation,* 37, 875–896. https://doi.org/10.1007/s11116-010-9267-z

Chilton, S., Covey, J., Jones-Lee, M., Loomes, G. and Metcalf, H. (2004). *Valuation of health benefits associated with reductions in air pollution.* London: Defra.

Clark, B., Chatterjee, K., Martin, A. and Davis, A. (2020). How commuting affects subjective wellbeing. *Transportation,* 47, 2777–2805. https://doi.org/10.1007/s11116-019-09983-9

Clark, A.E., Frijters, P. and Shields, M.A. (2008), 'Relative income, happiness, and utility: An explanation for the Easterlin paradox and other puzzles', *Journal of Economic Literature*, 46(1), 95-144.

Clark, A.E., Flèche, S., Layard, R., Powdthavee, N. and Ward, G. (2018). *The Origins of Happiness: The Science of Well-Being over the Life Course.* Princeton, NJ: Princeton University Press.

Crossrail Ltd (2005). *Economic Appraisal of Crossrail.* London: Crossrail Ltd. https://learninglegacy.crossrail.co.uk/wp-content/uploads/2023/04/Economic-Appraisal-of-Crossrail-2005.pdf

Dawson, D., Shaw, J. and Gehrels, W.R. (2016). Sea-level rise impacts on transport infrastructure: The notorious case of the coastal railway line at Dawlish, England. *Journal of Transport Geography*, 51, 97-109. https://doi.org/10.1016/j.jtrangeo.2015.11.009

Day, B., Bateman, I. & Lake, I. (2007). Beyond implicit prices: recovering theoretically consistent and transferable values for noise avoidance from a hedonic property price model, *Environmental and Resource Economics* 37, 211–232 (2007). https://doi.org/10.1007/s10640-007-9121-8

De Neve, J-E., and Ward, G. (2017). Happiness at work. In Helliwell, J.F., Layard, R., and Sachs, J. (eds), *World Happiness Report*. New York: Sustainable Development Solutions Network. https://s3.amazonaws.com/happiness-report/2017/HR17-Ch6_wAppendix.pdf

Department of Energy and Climate Change (DECC) (2009). *Carbon Valuation in UK Policy Appraisal: A Revised Approach*, July 2009. https://assets.publishing.service.gov.uk/media/5a7b7d4740f0b645ba3c4aa3/1_20090715105804_e____carbonvaluationinukpolicyappraisal.pdf

Department for Environment, Food and Rural Affairs (Defra) (2014). *Environmental noise: Valuing impacts on: sleep disturbance, annoyance, hypertension, productivity and quiet.* https://assets.publishing.service.gov.uk/media/5a7de374e5274a2e8ab44775/environmental-noise-valuing-imapcts-PB14227.pdf

Defra (2023). *Air quality appraisal: impact pathways approach*. Updated 2 March 2023. https://www.gov.uk/government/publications/assess-the-impact-of-air-quality/air-quality-appraisal-impact-pathways-approach

Defra (2023). *Enabling a Natural Capital Approach guidance*. https://www.gov.uk/government/publications/enabling-a-natural-capital-approach-enca-guidance/enabling-a-natural-capital-approach-guidance#introduction-to-natural-capital

Dekker, T., Finley, M. (eds) (2018). Programme for maintaining a robust valuation of travel time savings: feasibility study. Final Phase 2 Report. Leeds: Institute for Transport Studies. https://assets.publishing.service.gov.uk/media/5b225c29e5274a1908919eec/scoping-study-on-updating-values-of-travel-time-savings-phase-2.pdf

Dekkers, J.E.C. and van der Straaten, J.W. (2009). Monetary Valuation of Aircraft Noise: A Hedonic Analysis around Amsterdam Airport. *Ecological Economics,* 68(11): 2850–58.

Department for Energy Security and Net Zero (DESNZ) (2023). *Electricity Generation Costs 2023*. https://www.gov.uk/government/publications/electricity-generation-costs-2023

Department for Transport (DfT) (2015). *Understanding and valuing impacts of transport investment: values of travel time saving. Moving Britain ahead'*. https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/470998/Understanding_and_Valuing_Impacts_of_Transport_Investment.pdf

Department for Transport (DfT) (2017). *Value for Money Framework*. https://www.gov.uk/government/publications/dft-value-for-money-framework

Department for Transport (DfT) (2021). *Appraisal and Modelling Strategy: TAG update report.* https://assets.publishing.service.gov.uk/media/60b6383ad3bf7f435e3e1056/tag-update-report-2021.pdf

Department for Transport (DfT) (2022). *TAG Unit A4.3 Place-Based Analysis*. https://www.gov.uk/government/publications/tag-unit-a4-3-place-based-analysis

Department for Transport (DfT) (2022). *TAG Unit E-1 Evaluation*. https://www.gov.uk/government/publications/tag-unit-e-1-evaluation

Department for Transport (DfT) (2023). *TAG Data Book, v1.22.* https://www.gov.uk/government/publications/tag-data-book

Department for Transport (DfT) (2024), *COBALT v2.6 User Manual* https://www.tagsoftware.co.uk/COBALT

Department for Transport (DfT) (2024). *TAG Data Book, v1.23.* https://www.gov.uk/government/publications/tag-data-book

Department for Transport (DfT) (2019/22/3/4). *Transport Analysis Guidance (TAG)*. https://www.gov.uk/guidance/transport-analysis-guidance-tag

Dolan, P. and Metcalfe, R. (2008). *Comparing willingness-to-pay and subjective well-being in the context of non-market goods*. CEP Discussion Paper No. 890. London: Centre for Economic Performance, LSE.

Dubernet, I. and Axhausen, K. (2020). The German value of time and value of reliability study: the survey work. Transportation, 47, pp1477-1513.

Dupuit AJE (1844), 'De la mesure de l'utilité des travaux publics', Annales des Ponts et Chausées, 2e série, vol.8, Translated as: 'On the measurement of the utility of public works', *International Economic Papers*, 2, 83-110.

eftec (2019). *Feasibility study for the valuation of forest biodiversity.* https://forestry.gov.scot/publications/736-feasibility-study-for-the-valuation-of-forest-biodiversity

eftec (2017*). A study to scope and develop urban natural capital accounts for the UK.* http://randd.defra.gov.uk/Document.aspx?Document=14143_UrbanNC_Account_FinalReportAugust2017.pdf

Eliasson, J. (2020). "Reconciling Accessibility Benefits with User Benefits," International Transport Forum Discussion Papers 2020/21, OECD Publishing. https://doi.org/10.1787/b6458e9b-en

Evans, M.F. and Taylor, L.O. (2020). Using revealed preference methods to estimate the value of reduced mortality risk: Best practice recommendations for the hedonic wage model, *Review of Environmental Economics and Policy*. 14(2), 282-301.

Flatley, J. (2015). *Crime Statistics, Focus on Public Perceptions of Crime and the Police, and the Personal Well-being of Victims: 2013 to 2014*. London: Office for National

Statistics. https://www.ons.gov.uk/peoplepopulationandcommunity/crimeandjustice/compendium/crimestatisticsfocusonpublicperceptionsofcrimeandthepoliceandthepersonalwellbeingofvictims/2015-03-26

Flugel, S., Weber, C., Halse, A.H. & Ellis, I.O. (2022*). Valuation based on big data and revealed preference: an assessment for Norwegian transport appraisal.* Institute of Transport Economics, Norwegian Centre for Transport Research. https://www.toi.no/getfile.php?mmfileid=73095

Fransen, K., Boussauw, K., Deruyter, G., De Maeyer, P. (2019). The relationship between transport disadvantage and employability: Predicting long-term unemployment based on job seekers' access to suitable job openings in Flanders, Belgium, *Transportation Research Part A: Policy and Practice*, 125, 268-279. https://doi.org/10.1016/j.tra.2018.01.023

Frijters, P. and Krekel, C. (2021). *A Handbook for Wellbeing Policy-Making: History, Theory, Measurement, Implementation, and Examples* 1st ed. Oxford: Oxford University Press.

Fujiwara, D. (2013). *A General Method for Valuing Non-market Goods Using Wellbeing Data: Three-Stage Wellbeing Valuation*. CEP Discussion Paper No. 1233. London School of Economics.

Fujiwara, D. (2016). *Social Impact Valuation.* Presentation to New Zealand Treasury, 4/5 August 2016*.* https://www.treasury.govt.nz/sites/default/files/2016-07/tgls-fujiwara-slides.pdf

Fujiwara, D. and Dass, D. (2021). Incorporating life satisfaction in discrete choice experiments to estimate wellbeing values for non-market goods. London: Simetrica-Jacobs. https://uploads-ssl.webflow.com/6274e0c5fb041327b2d5e532/6274e0c5fb041364efd5e6c2_Life-satisfaction-in-DCE.pdf

Fujiwara, D. and Dolan, P. (2016). Happiness-Based Policy Analysis. In: Adler, M.D. and Fleurbaey, M. (eds), *The Oxford Handbook of Well-Being and Public Policy*. Oxford University Press.

Fujiwara, D., Houston, D., Keohane, K., Gramatki, J. and Maxwell, C. (2018). *Valuation of the impact of roadworks and flooding using the Wellbeing Valuation method.* Report presented to Anglian Water. London: Simetrica.

GBD Collaborators (2019). Global burden of 369 diseases and injuries in 204 countries and territories, 1990-2019: a systematic analysis for the Global Burden of Disease Study 2019. *Lancet,* 396(10258):1204-1222. https://doi.org/10.1016/S0140-6736(20)30925-9.

Geurs, K. and van Wee, B. (2004). Accessibility evaluation of land-use and transport strategies: Review and research directions. *Journal of Transport Geography*, 12(2), 127-140. https://doi.org/10.1016/j.jtrangeo.2003.10.005

Geurs, K.T., Haaijer, R. and van Wee, B. (2006). The option value of public transport: methodology for measurement and case study for regional rail links in the Netherlands. *Transport Reviews*, 26 (5), 613–643. https://doi.org/10.1080/01441640600655763

Geurs, K., Zondag, B., de Jong, G., & de Bok, M. (2010). Accessibility appraisal of land-use/transport policy strategies: More than just adding up travel-time savings. *Transportation Research Part D: Transport and the Environment*, 15(7), 382-393.

Gobind, J. (2018). Transport anxiety and work performance. *SA Journal of Human Resource Management*, 16(0), a943. https://doi.org/10.4102/sajhrm.v16i0.943

Hamermesh, Daniel S. (2017). Replication in Labor Economics: Evidence from Data and What It Suggests. *American Economic Review* 107.5, 37–40. https://doi.org/10.1257/aer.p20171121

Handy, S. (2020). Is accessibility an idea whose time has finally come?. *Transportation Research Part D: Transport and Environment*, 83, 102319.

Hanslmaier, M. (2013). Crime, Fear and Subjective Wellbeing: How Victimization and Street Crime Affect Fear and Life Satisfaction. *European Journal of Criminology,* 10: 515–33.

Heeks, M., Reed, S., Tafsiri, M. and Prince, S. (2018*). The economic and social costs of crime, Second edition.* Research Report 99. London: The Home Office. https://assets.publishing.service.gov.uk/media/5b684f22e5274a14f45342c9/the-economic-and-social-costs-of-crime-horr99.pdf

HM Treasury (2020) *Magenta Book: Central Government guidance on evaluation*. London: HM Treasury. https://assets.publishing.service.gov.uk/media/5e96cab9d3bf7f412b2264b1/HMT_Magenta_Book.pdf

HM Treasury (2021a). *Wellbeing Guidance for Appraisal: Supplementary Green Book Guidance.* London: HM Treasury. https://assets.publishing.service.gov.uk/media/60fa9169d3bf7f0448719daf/Wellbeing_guidance_for_appraisal_-_supplementary_Green_Book_guidance.pdf

HM Treasury (2021b). *Wellbeing discussion paper: monetisation of life satisfaction effect sizes - A review of approaches and proposed approach.* London: HM Treasury https://assets.publishing.service.gov.uk/media/60fa91c68fa8f50431ca80da/Wellbeing_guidance_for_appraisal_-_background_paper_reviewing_methods_and_approaches.pdf

HM Treasury (2022), The Green Book: Appraisal and Evaluation in Central Government https://www.gov.uk/government/publications/the-green-book-appraisal-and-evaluation-in-central-government

Horowitz, J.K. and McConnell, K.E. (2002). A review of WTA/WTP studies. *Journal of Environmental Economics and Management*, 44, 426–447.

Humphreys, M. and Fowkes, A. S. (2006). The significance of indirect use and non-use values in transport appraisal. *International Journal of Transport Economics*, 33(1), 17–35. http://www.jstor.org/stable/42747776

Jiang, L. and Nellthorp, J. (2020). Valuing transport noise impacts in public urban spaces in the UK: Gaps, opportunities and challenges. *Applied Acoustics*, 166, 107376. https://doi.org/10.1016/j.apacoust.2020.107376

Johnston, D. W., Shields, M. A. and Suziedelyte, A. (2017). Victimisation, Wellbeing and Compensation: Using Panel Data to Estimate the Costs of Violent Crime. *Economic Journal,* 128: 1545–69.

Johnston, R.J., Boyle, K.J., Adamowicz, W., Bennett, J., Brouwer, R., Cameron, T.A., Hanemann, W.M., Hanley, N., Ryan, M., Scarpa, R. and Tourangeau, R. (2017). Contemporary guidance for stated preference studies. *Journal of the Association of Environmental and Resource Economists*, 4(2), 319-405.

Jones, P., Boujenko, N. and Marshall, S. (2007). *Link & Place: A Guide to Street Planning and Design.* London: Local Transport Today.

Kahneman, D. and Tversky, A. (1979). Prospect theory: An analysis of decision under risk. *Econometrica*, 47(2), 263–91.

Krekel, C. and MacKerron, G. (2023). *Back to Edgeworth? Estimating the value of time using hedonic experiences.* Discussion Paper No. 1932. London: Centre for Economic Performance, LSE. https://cep.lse.ac.uk/_NEW/publications/abstract.asp?index=10288

Kroesen, M. and De Vos, J. (2020). Does active travel make people healthier, or are healthy people more inclined to travel actively?, *Journal of Transport & Health*, 16. https://doi.org/10.1016/j.jth.2020.100844

Laird, J.J., Batley, R.P., Nash,C.A. and Geurs, K. (2006). *Option values, non-use values and transport appraisal.* Report to the Department for Transport. Leeds: Institute for Transport Studies.

Laird, J., Geurs, K. and Nash, C. (2009). Option and non-use values and rail project appraisal. *Transport Policy*, 16(4), 173–182. https://doi.org/10.1016/j.tranpol.2009.05.002

Lawton, R. and Fujiwara, D. (2016). Living with aircraft noise: Airport proximity, aviation noise and subjective wellbeing in England. *Transportation Research Part D: Transport and Environment*, 42, 104-118. https://www.sciencedirect.com/science/article/pii/S1361920915001959?via=ihub

Layard, R., Mayraz, G. and Nickell, S. (2006). *The marginal utility of income*. London: Centre for Economic Performance, London School of Economics.

Layard, R., Mayraz, G. and Nickell, S. (2008). The marginal utility of income, *Journal of Public Economics*, 92 (8–9), 1846-1857. https://doi.org/10.1016/j.jpubeco.2008.01.007

Layard, R. (2009). Well-Being Measurement and Public Policy. In: Krueger, A.B. (ed) *Measuring the Subjective Well-Being of Nations: National Accounts of Time Use and Well-*

Being, Ch.16, pp.145-154. Chicago: University of Chicago Press. https://www.nber.org/system/files/chapters/c5058/c5058.pdf

Layard, R., Mayraz, G. and Nickell, S. (2009). *Does relative income matter? Are the critics right?*, CEP Discussion Paper 918. London: Centre for Economic Performance, LSE.

Layard, R. (2016). Measuring Wellbeing and Cost-effectiveness Analysis Using Subjective Wellbeing. London: What Works Centre for Wellbeing. https://whatworkswellbeing.org/wp-content/uploads/2020/01/common-currency-measuring-wellbeing-series-1-dec-2016v3.pdf

Layard, R. and De Neve, J.-E. (2023). *Wellbeing : science and policy,* 1st ed. Cambridge, UK: Cambridge University Press.

Levinson, A. (2012). Valuing Public Goods Using Happiness Data: The Case of Air Quality. *Journal of Public Economics,* 96, 869–80.

Luechinger, S. (2009). Valuing Air Quality Using the Life Satisfaction Approach. *Economic Journal,* 119, 482–515.

Lupi, F., Phaneuf, D.J. and von Haefen, R.H. (2020). Best practices for implementing recreation demand models. *Review of Environmental Economics and Policy*, 14(2), 173-369.

MacKerron, G. and Mourato, S. (2009). Life satisfaction and air quality in London. *Ecological Economics*, 68(5), 1441-1453.

MacKerron, G. and Mourato, S. (2020). Chapter 14: Mappiness: natural environments and in-the-moment happiness. In: Maddison, Rehdanz & Welsch (eds), *Handbook on Wellbeing, Happiness and the Environment,* 266–282. Cheltenham: Edward Elgar.

Mackie, P.J. and Worsley T. (2013). *International Comparisons of Transport Appraisal Practice: Overview Report.* Leeds: Institute for Transport Studies. https://assets.publishing.service.gov.uk/media/5a7c5328e5274a1b00423016/final-overview-report.pdf

Mackie, P.J. and Worsley T. (2023). Transport Appraisal – Retrospective and Prospective, *Journal of Transport Economics and Policy*, 57(4), 2023, 305–323.

McFadden, D. and Train, K. (2017). *Contingent Valuation of Environmental Goods: A Comprehensive Critique*. Cheltenham: Edward Elgar.

Mele, C., Russo-Spena, T., Tregua, M., and Pels, J. (2023). A Value-Based Well-Being Framework. *Journal of Macromarketing*, 43(1), 85-97. https://doi.org/10.1177/02761467221105190

Mervin, M. C., & Frijters, P. (2014). Is shared misery double misery? *Social Science & Medicine*, 107, 68–77.

Millard, T., Nellthorp, J. and Ojeda Cabral, M. (2018). What is the value of urban realm? - a cross-sectional analysis in London. Paper presented at the International Transportation Economics Association Conference, Hong Kong, 25-29 June 2018.

Mott MacDonald (2013). *Valuing the social impacts of public transport: Final report.* Birmingham: Mott Macdonald. https://assets.publishing.service.gov.uk/media/5a7ccf45e5274a2c9a4843f4/final-report.pdf

Mouter, N., Koster, P. and Dekker, T. (2021). Contrasting the recommendations of participatory value evaluation and cost-benefit analysis in the context of urban mobility investments. *Transportation Research Part A: Policy and Practice*, 144, 54-73.

Mukuria, C., Rowen, D., Peasgood, T. and Brazier, J. (2014). *An empirical comparison of well-being measures used in UK.* Sheffield: University of Sheffield. https://eprints.whiterose.ac.uk/99499/1/EEPRU%20Report%20-%20Empirical%20comparison%20of%20well-being%20measures%20version%20interim%20report.pdf

Nellthorp, J. and Batley, R. (2004). Does a Model of Individual Willingness to Pay Need the Concept of Utility? Paper presented at the European Transport Conference, Strasbourg, 5th Oct 2004.

Nellthorp, J., Bristow, A.L. & Day, B. (2007). Introducing Willingness-to-Pay for Noise Changes into Transport Appraisal: An Application of Benefit Transfer, *Transport Reviews*, 27:3, 327-353. https://doi.org/10.1080/01441640601062621

Nellthorp, J. (2017), The principles behind transport appraisal. In: Cowie, J. & Ison, S. (eds) *Routledge Handbook of Transport Economics*, Ch.12, pp.176-208. Abingdon: Routledge.

Nellthorp, J., Ojeda Cabral, M., Johnson, D., Leahy, C. and Jiang, L. (2019). *Land Value and Transport (Phase 2): Modelling and Appraisal.* Final Report to TfN, WYCA and EPSRC. Leeds: Institute for Transport Studies, University of Leeds. https://doi.org/10.5518/100/18

Nellthorp, J. (2023). *Estimating the benefits of active travel investment.* Report for Active Travel England. Leeds: Institute for Transport Studies.

NICE (2012). *The guidelines manual: process and methods.* Chapter 7: Assessing cost effectiveness. https://www.nice.org.uk/process/pmg6/chapter/assessing-cost-effectiveness

Nordic Council of Ministers (2021). *Towards a Nordic Wellbeing Economy.* https://www.norden.org/en/publication/towards-nordic-wellbeing-economy

OECD (2013). *Guidelines on Measuring Subjective Well-being*. Paris: OECD Publishing. https://www.oecd.org/wise/oecd-guidelines-on-measuring-subjective-well-being-9789264191655-en.htm

OECD (2018). *Cost-Benefit Analysis and the Environment*. Paris: OECD Publishing. https://www.oecd.org/env/cost-benefit-analysis-and-the-environment-9789264085169-en.htm

Ojeda-Cabral, M., Batley, R., Calastri, C., Dekker, T., Matthews, B., Phillips, I. and Jiang, L. (2023*). National Railway Accessibility Strategy: Economics Benefits Framework.* Report for GBRTT and RSSB. https://www.rssb.co.uk/research-catalogue/CatalogueItem/COF-ECO-14

Pevec, D., Babic, J., Carvalho, A., Ghiassi-Farrokhfal, Y., Ketter, W., Podobnik, V. (2020). A survey-based assessment of how existing and potential electric vehicle owners perceive range anxiety, *Journal of Cleaner Production*, 276, 122779. https://doi.org/10.1016/j.jclepro.2020.122779

Rayo, L. and Becker, G.S. (2007). Evolutionary efficiency and happiness, *Journal of Political Economy*, 115(2), 302-337.

Ricardo-AEA (2019). *Production of Updated Emission Curves for Use in the NTM and WebTAG, SPaTS Work Package 1-650* https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/942830/Production_of_Updated_Emission_Curves_for_Use_in_the_NTM_and_WebTAG-document.pdf

Richardson, J., Chen, G., Khan, M.A. & Iezzi, A. (2014). *Subjective Wellbeing versus Utility: incommensurable or mismeasured constructs*. Monash University, Centre for Health Economics, Working Paper 04-14.

Sagger, H., Philips, J. and Haque, M. (2021). *Valuing culture and heritage capital: a framework towards informing decision making*. London: DCMS. https://www.gov.uk/government/publications/valuing-culture-and-heritage-capital-a-framework-towards-decision-making/valuing-culture-and-heritage-capital-a-framework-towards-informing-decision-making

Salomon, J. A. et al. (2015). Disability weights for the Global Burden of Disease 2013 study. *The Lancet Global Health*, 3(11), pp 712-723.

Scott, N., Szydlowska, A., Behzadnejad, F., Malde, J., Lawton, R. and Fujiwara, D. (2020). *Aviation Noise & Subjective Wellbeing*, Draft Report to DfT. London: Simetrica Jacobs.

Stead, I. and Cheyney, C. (2023). 'Investigating distributive weighting in UK transport appraisal'. Presentation at TAG Conference, 9th October 2023.

Sugden, R. (1999). *Developing a consistent cost-benefit framework for multi-modal transport appraisal.* A report for the Department of the Environment, Transport and the Regions. Norwich: University of East Anglia. https://ueaeprints.uea.ac.uk/id/eprint/84110/1/1999_consistent_CBA_framework.pdf

Sugden, R. (2003). Conceptual Foundations of Cost-benefit Analysis: A Minimalist Account. In: Pearman, A., Mackie, P. and Nellthorp, J. (2003). *Transport Projects, Programmes and Policies: Evaluation Needs and Capabilities.* Abingdon: Routledge.

Tunçel, T. and Hammitt, J.K. (2014). A new meta-analysis on the WTP/WTA disparity. *Journal of Environmental Economics and Management*, 68, 175-187.

VanderWeele, T.J., Trudel-Fitzgerald, C., Allin, P., Farrelly, C., Fletcher, G., Frederick, D.E., Hall, J., Helliwell, J.F., Kim, E.S., Lauinger, W.A. and Lee, M.T. (2020). Current recommendations on the selection of measures for well-being. *Preventive Medicine*, 133, 106004.

Venables, A.J., Laird, J.J. and Overman, H. (2014). *Transport investment and economic performance: implications for project appraisal*. Report to DfT. https://assets.publishing.service.gov.uk/media/5a74fd3be5274a3cb2868cad/TIEP_Report.pdf

Wardman, M. (2014). *Valuing Convenience in Public Transport: Roundtable Summary and Conclusions*. Discussion Paper 2014-02. Paris: OECD. https://www.itf-oecd.org/sites/default/files/docs/dp201402.pdf

Wardman, M., Chintakayala, V.P.K. and De Jong, G.C. (2016). Values of travel time in Europe: Review and meta-analysis. *Transportation Research Part A: Policy and Practice*, 94, 93-111.

What Works Centre for Local Economic Growth (WWCLEG) (2015). *What Works Centre Evidence Review 7: Transport*. https://whatworksgrowth.org/resource-library/transport/

What Works Wellbeing (2017). *Systematic scoping review of indicators of community wellbeing in the UK*, VERSION 1.2. https://whatworkswellbeing.org/wp-content/uploads/2020/02/community-wellbeing-indicators-scoping-review-v1-2-aug2017_0205746100.pdf

What Works Wellbeing (2019). *Heritage and wellbeing: The impact of historic places and assets on community wellbeing - a scoping review.* Technical Report. https://whatworkswellbeing.org/wp-content/uploads/2020/01/Heritage-scoping-review-March-2019-1.pdf

White, M.P., Alcock, I., Wheeler, B.W. and Depledge, M.H. (2013). Would you be happier living in a greener urban area? A fixed-effects analysis of panel data. *Psychological Science*, 24, 920-928.

WSP (2020). *Biodiversity Net Gain: Financial and Economic Appraisal for Major Infrastructure Projects. Report to Defra.* Basingstoke: WSP. https://randd.defra.gov.uk/ProjectDetails?ProjectID=20490&FromSearch=Y&Publisher=1&SearchText=NE0146&SortString=ProjectCode&SortOrder=Asc&Paging=10#Description

Zapata-Diomedi, B., Gunn, L., Giles-Corti, B., Shiell, A. and Veerman, L. (2018). A method for the inclusion of physical activity-related health benefits in cost-benefit analysis of built environment initiatives. Preventive Medicine, 106, 224-230. https://doi.org/10.1016/j.ypmed.2017.11.009

Zizzo, D.J. and Oswald, A.J. (2001). Are people willing to pay to reduce others' incomes?, *Annales d'Economie et de Statistique*, 63-64, 39-65.

Appendix 1 – Pro-formas for travel time and noise impacts

DfT Wellbeing Review - Pro-forma
Impact: Travel time (non-work)
Sub-impacts: time spent in different conditions (e.g. in-vehicle, congested/uncongested, PT waiting, access/egress)

TAG Units	A1.3 User and Provider Impacts
TAG Data Book	Table A1.3.1
Underpinning evidence documents	Arup, ITS & Accent (2015). 'Department for Transport - Provision of market research for value of travel time savings and reliability: Phase 2 Report', available at: https://assets.publishing.service.gov.uk/media/5a7ffa11ed915d74e622bbe3/vtts-phase-2-report-issue-august-2015.pdf Batley, R.P. et al. (2017). New appraisal values of travel time saving and reliability in Great Britain. Transportation, 46, 583-621. Börjesson, M. and Eliasson, J. (2019). Should values of time be differentiated? Transport Reviews, 39(3), 357-375. Dekker et al. (2017). Programme for maintaining a robust valuation of travel time savings: feasibility study. Report to DfT. November 2017. Wardman, M., Chintakayala, V.P.K. and De Jong, G.C. (2016). Values of travel time in Europe: Review and meta-analysis. Transportation Research Part A: Policy and Practice, 94, 93-111.
Key evidence documents - SWB methods	Krekel, C. and MacKerron, G. (2023). Back to Edgeworth? Estimating the Value of Time Using Hedonic Experiences. https://cep.lse.ac.uk/pubs/download/dp1932.pdf Clark, B., Chatterjee, K., Martin, A. and Davis, A. (2020). How commuting affects subjective wellbeing, Transportation, 47, 2777–2805. Chatterjee, K., Chng, S., Clark, B., Davis, A. De Vos, J., Ettema, D., Handy, S., Martin. A. and Reardon, L. (2020). Commuting and wellbeing: a critical overview of the literature with implications for policy and future research, Transport Reviews, 40(1), 5-34. Dickerson, A., Hole, A.R. and Munford, L.A. (2014). The relationship between well-being and commuting revisited: Does the choice of methodology matter?. Regional Science and Urban Economics, 49, 321-329.
Valuation data	SP: TAG values based on choice data from a set of hypothetical discrete choice experiments (DCE) described in Batley et al (2017), Table 2. Modes include: car; bus; rail; other PT; walk and cycle (require further research). Purposes include business (see separate pro-forma), commute and other non-work. Attributes include: travel time; travel cost; travel time reliability; traffic (free-

	flow to heavy); crowding; frequency; distance; person characteristics (incl. age, gender, employment status, household composition and income); and geography. General public: data from 8,623 interviews (multiple questions per interview) (Employers: 400 interviews - see the VTTS Business pro-forma). RP: TAG values use RP data for validation, however "the RP analysis proved extremely challenging, and only limited insights could be gleaned in terms of validation of the SP". Data gives choice of rail operator on select routes to London, where travel time and cost (and other attributes) vary. SWB: Not so far used in TAG valuations. K&M (2023) used the Mappiness dataset containing happiness (0..100) and other variables for 2010-2017. General public: 30,936 people (average 72 observations per person, at random times, 8.98% of total observations were in 'Travelling, commuting' time - K&M Table 1) - 2,235,733 total observations, both travel and non-travel observations are needed for this method. Clark et al (2020) use six waves of Understanding Society from 2009/10 to 2014/15, containing life satisfaction (1..7) as well as relevant domain satisfactions (job satisfaction and leisure time satisfaction), plus health metrics. General public: 26,551 people, 79,793 observations. Dickerson et al. (2014) use British Household Panel Survey (BHPS) data from 1996–2008 including life satisfaction and leisure time satisfaction. General public: 9,930 people, 62,786 observations.
Valuation methods	SP: Discrete choice modelling incorporated "developments, relating to the error structure of the models, the treatment of reference dependence (size and sign effects) and the incorporation of unobserved preference heterogeneity in valuations" (Batley et al, 2017) SWB: All of the following studies conducted regressions with wellbeing as the dependent variable and travel time, and other variables, as the independent variables. K&M (2023): OLS regression of a wellbeing function including binary variables for 'Travel, commuting' and other activities (non-exclusive); a separate auxiliary regression including log income (only one observation per person, at intake survey stage). 'Value of Time'=(MRStravel,income - MRSother activities,income)*Income per hour e.g. for time savings in 'travel, commuting': =((-1.86/0.0091)-(1.8177/0.0091))* 182/365/24 = £8.40/hour Note the assumption of a 1% income change - this has been applied to the income (£18,200p.a.) and to the MUincome coefficient (0.91 happiness units) so it washes out. The coefficient 1.8177 is not stated in the paper, it is inferred from the VTTS result given (£8.40/hr) and the other parameters. The value of wait time while travelling is calculated by re-estimating the regression model including interaction terms (only between waiting and each other activity). The first MRS in the formula becomes: MRStravel+wait,income = (dU/d(Wait&Travel))+ (dU/d(Wait))+ (dU/d(Travel)) dU/dIncome VTTSwait=(MRStravel+wait,income - MRSother activities,income)*Income per hour =((-5.71/0.009)-(2.89/0.009))*0.0003*60 = £17.19/hour (Note: there may be a rounding error in this result, due to the 0.0003 term, and the value should be approx. £19.63/hr).

<table>
<tr><td></td><td>Although the survey contains a 'Working, studying' activity which can be combined with other activities, the regression has not been re-run for interactions between work and travel, or work, travel and waiting.
In any case there is an issue as to whether 'Working, studying' captures all travel on employer's business - respondents may perceive it as travel and not as work or study, depending perhaps on what they are actually doing while travelling.
The obvious short term solution is to re-estimate the regression model for interactions between:
work & travel
work, travel and waiting.

Plus others - see below, e.g. 'in vehicle', 'indoors', 'outdoors'; 'walking'.

The longer term solution is to include additional questions in the new survey - also see below.

Clark et al (2020): Attempted to measure the impact of commuting on life satisfaction through panel regression, with additional mediated regressions including job satisfaction and leisure time satisfaction as additional controls. Used a correlated random effects model (variant of fixed effects). Also investigated using job satisfaction or leisure time satisfaction as the dependent variable.</td></tr>
<tr><td>Strengths & weaknesses of current methods</td><td>...including capability to capture the full impact.

Context and relevance:
Current methods provide preference utility-based valuations. For comparison, SWB approaches rely on experiential (happiness) or evaluative wellbeing (life satisfaction) data. The use of RP as a validation check was limited to rail in the most recent VTTS study (Batley et al, 2017).
<table>
<tr><td></td><td colspan="2">Preference Utility approaches</td><td colspan="2">SWB approaches</td></tr>
<tr><td>Key source</td><td colspan="2">Batley et al (2017)</td><td>Krekel & McKerron (2023)</td><td>Clark et al (2020)</td></tr>
<tr><td>Data type</td><td>SP</td><td>RP</td><td>Experiential (Happiness)</td><td>Life Satisfaction</td></tr>
<tr><td>Survey data</td><td>Choice experiments</td><td></td><td>Mappiness app / NESSy</td><td></td></tr>
<tr><td>Existing datasets</td><td></td><td>LENNON ticket sales data (rail)</td><td></td><td>Understanding Society</td></tr>
<tr><td>Modes</td><td>Car, Bus, Rail, Other PT, Walk, Cycle</td><td>Rail</td><td>–
(not modal)</td><td>Drive by car or van, Car or van pax, M/c, Taxi, Bus, Train, Metro, Cycle, Walk, Other</td></tr>
</table>
Modal coverage is wide using current methods. Clark et al (2020) also address a wide range of modes. K&M (2023) is mostly non-modal.
<table>
<tr><td>Modes – potential, short term
- re-analysis of data</td><td></td><td></td><td>'Walking, hiking' variable (binary)

'Sports, running, exercise' (binary)</td><td></td></tr>
<tr><td>Modes – potential, long term</td><td></td><td></td><td>Add questions to NESSy to establish Mode</td><td></td></tr>
</table>
Working conclusions: (i) there is little that can be done in the short term (except interaction terms with the 'walk' and 'exercise' variables), but (ii) in long term, NESSy data could include a Mode question.
Trip purposes are methodically analysed in TAG, and the categories are evidence-based. SWB studies so far do not fully address this: the Mappiness app combined "travelling, commuting"; and Clark et al focused exclusively on commuting.</td></tr>
</table>

Trip purposes	Commute, Other non-work, Employer's business	Commute, Other non-work, Employer's business	"Travelling, commuting" (1 variable) 'Working, studying" (1 variable)	Commute
Trip purposes – *potential, short term - re-analysis of data*			Variable is not suitable for identifying EB trips	
Trip purposes – *potential, long term*			Add questions to NESSy to establish Trip Purpose	Add questions to surveys: on EB & Other Non-Work travel time

Working conclusions: (iii) potentially add question to NESSy to establish Trip Purpose (Business, Commute, Other Non-Work); (iv) and to Understanding Society about time spent in EB & Other Non-Work travel, or explore Time Use Survey data.
Trip stage is included in Wardman et al (2016). K&M (2023) provides a value of waiting time while travelling. The Mappiness data includes a variable which could be used to identify In-Vehicle time, but this is not done. Clark et al do not consider trip stage at all.

Trip stage	Not addressed in this study but in Wardman et al (2016): • access; wait; IVT; interchange		"Waiting, queueing' while 'Travelling, commuting' value ('In-vehicle'/'Indoors' /'Outdoors' variable collected but not analysed with the others)	– (not addressed)
Trip stage – *potential, short term - re-analysis of data*			Explore interacting with 'In-vehicle'/ 'Indoors'/'Outdoors' variable	
Trip stage – *potential, long term*			Add questions to NESSy to establish Trip Stage	

Working conclusions: (v) re-analyse dataset for interaction with 'In vehicle'; (vi) potentially add question to NESSy to establish Trip Stage (Access, Wait, IVT, Interchange, Egress).

Travel conditions - particularly traffic congestion and crowding on PT - are included in Batley et al (2017). Neither K&M (2023) nor Clark et al (2020) consider travel conditions.

Travel conditions	Traffic conditions: free-flow / light traffic / heavy traffic. Crowding (seating, standing).		Only "Waiting, queueing' variable	– (not addressed)
Travel conditions – *potential, short term - re-analysis of data*			–	
Travel conditions – *potential, long term*			Add questions to NESSy to establish PT crowding and trafic conditions (caveat: driving and app use)	

Working conclusion: (vi) potentially add questions to NESSy to establish travel conditions (crowding, traffic congestion).

Other aspects that are addressed by current methods are reliability, size and sign effects, and losses vs gains. The SWB studies do not directly address these aspects.

Accuracy and confidence intervals:
95% confidence intervals around the TAG VTTS are given in Arup, ITS and Accent (2015), Section 7.7.
Based on this underlying research evidence, TAG Unit A1.3 recommends sensitivity testing to +/-25% for Business and Commute time, and +/-60% for Non-Work.

	Krekel & McKerron (2023) give standard errors separately for the coefficients on 'Travelling, commuting' and on income, but not for the interaction term with 'Waiting, queueing'. Confidence intervals for the 'VOT' are not provided, and would be helpful. A concern is the income coefficient, which is estimated using an essentially cross-sectional auxiliary regression since each respondent was only asked the income question once, in the intake survey. Moreover, the authors compare the income coefficient with just one US study. Clark et al (2020) find that the relationship between commute time and life satisfaction is insignificant. This accords with some of the wider literature, including Dickerson et al (2014). They find highly significant relationships with domain satisfactions for Job Satisfaction and Leisure Time satisfaction (>99%), and they speculate about why this fails to feed through into a measurable impact on Life Satisfaction. They state: “Workers in England appear to be successful in balancing the negative aspects of commuting against the wider benefits, e.g. access to employment, earnings and housing”. This echoes Dickerson et al (2014) who state: “According to microeconomic theory, individuals would not choose to have a longer commute unless they were compensated for it in some way, either in the form of improved job characteristics (including pay) or better housing prospects (Stutzer and Frey, 2008). Even if commuting in itself is detrimental to well-being we would therefore not expect individuals with longer commutes to report lower levels of life satisfaction”. The value derived from the Job Satisfaction variable in the Clark et al (2020) paper is extremely high (approx. seven-fold what we would expect based on preference utility studies and the K&M happiness-based study). Causality: Krekel & McKerron (2023) do not claim causality, as there is no exogenous source of variation (e.g. in travel time). However, the estimation of an individual fixed effects model and the stability of the coefficients across different models are encouraging. The K&M (2023) approach is rather more explicit than the current TAG approach about the set of other activities an individual may be doing other than travelling, and the allocation of time across activities is quantified. On the other hand, this is only the average allocation of time. What we do not know is the allocation of a marginal unit of time transferred from travel time. The Hensher approach is more explicit about this, and choice models allow for questioning about what the respondent would do with the time saved. Ability to handle hypotheticals/future changes: SP: excellent - levels of all attributes can be varied, and simulation, virtual reality help to communicate alternative realities (e.g. emerging modes, and differing travel conditions). What may be of more concern is to what extent the respondent is able to think through all the consequences for themselves of a change in travel behaviour - e.g. changes in vehicle ownership, work and residential location choices. Pivoting from the situation 'as now' is one way of avoiding over-burdening the respondent. SWB: Insofar as values vary by mode, trip purpose, trip stage and travel conditions, these are mostly missing from the values so far. The ability to vary these attributes outside the range of recent experience may rely again on simulation. Transferability: The SWB studies are based on UK data and control carefully for geography and personal characteristics. However, the lack of detail in terms of journey attributes makes them very 'averaged' values and inevitably less accurate when applied to one real intervention or another. The SP studies also contain many control variables for which could be used for segmentation of the values, if that was considered to be desirable in appraisal. Biases: Meta-analysis has been used, e.g. in Wardman et al (2016), to identify and address any biases evident in particular methods. The current TAG values are believed to be a good reflection of a body of SP and RP evidence across UK and international studies.

	External validility of the Mappiness dataset has been checked by K&M against Understanding Society, and the sample was found to be slightly biased towards younger (25-44 year olds) and "tech savvy" people. Clark et al (2020) used the Understanding Society dataset itself. Other methodological issues: -
Potential for SWB valuation	Form(s) of wellbeing that could be relevant: All (LS, worthwhile, happiness, anxiety) LS preferred for CBA The existence of evidence: Yes - particularly K&M (2023) and Clark et al (2020). However, the failure to find a significant LS coefficient and the order of magnitude issue with the implied value of time in the Clark et al study, mean that the K&M study is the most immediately useful. The prospect of developing new evidence: As above, there are questions that could be included in a new Mappiness-style study (NESSy) to enable valuation work on travel time, overcoming issues identified above. There is also some (limited) scope for reanalysis of the Mappiness dataset. Life Satisfaction is where we want to find evidence of SWB impacts of transport interventions, however this remains unproven in the main LSA study to date. Risk of double counting: For VTTS, the methods are clearly alternatives. Double counting is not believed to be an issue. Opportunity for validation/cross-referencing between valuation methods: Yes, clear opportunity to add happiness-based evidence to the overall evidence base. See spreadsheet for empirical comparisons [see Table 8 in this report - main text]. Overall pros and cons relative to preference-based evidence: The happiness-based approach may be useful in future to help clarify the role of modal disutilities versus income in VTTS by mode. It may also help to explore how individuals value travel experience across many modes (a related point). It may help to segment the VTTS - although this is already done extensively using SP. On the other hand, there are concerns around the income coefficient, the use of a weighted average mix of activities to reallocate saved time, and the lack of exogenous variation in travel time in the method (causality). The empirical comparison may be reasonably close because the methods do in fact align theoretically, or by coincidence. This requires careful investigation.
Use of SWB valuation in forecasting and appraisal	How would the valuations be used in practice and would the effort to do so be proportionate? In the same way as current VTTS. How would the SWB measures be linked to transport models? As now, through a welfare-based VTTS.
Forecasting tools available	Yes - existing transport modelling tools to forecast travel time changes.
Segmentation for distributional analysis	Definitely an area of interest for VTTS. Both the current SP/RP approaches and the Happiness-based approach offer values with a great deal of segmentation. Whether to use them is partly limited by the capability of transport models. Segmented values may be of particular relevance in Distributional Impact analysis.

	<table><tr><td></td><td colspan="2">Preference Utility approaches</td><td colspan="2">SWB approaches</td></tr><tr><td>Key source</td><td colspan="2">Batley et al (2017)</td><td>K&M (2023)</td><td>Clark et al (2020)</td></tr><tr><td>Data type</td><td>SP</td><td>RP</td><td>Experiential (Happiness)</td><td>Life Satisfaction</td></tr><tr><td>Segmentation</td><td>Person: • age, gender, employment status, household composition, income Geography. Trip: • distance, other activities (while travelling).</td><td></td><td>Person: • age, gender, emplom't, rel'ships, hh composition, health, income. Geography. Trip: • accompanied (by whom), weather, other activities (while travelling).</td><td>Person: • age, gender, health, income, ethnicity, household, tenure, religion, education, employment hours and type. Geography.</td></tr><tr><td>Segmentation – potential, short term</td><td></td><td></td><td>Potential to explore how VTTS changes with 'accompanied'.</td><td></td></tr><tr><td>Segmentation – potential, long term</td><td>Potential to explore how VTTS changes with 'accompanied'.</td><td></td><td>Add questions to NESSy to establish trip distance; prompt for other likely act-ivities while travelling.</td><td></td></tr></table> Working conclusions: potentially add question to NESSy on trip distance (vii); and prompt on activities while travelling (viii).
Potential to incorporate SWB within TAG	Yes: Happiness-based values as part of a wider set of evidence across methods (validation); and/or to allow greater segmentation - which could also be pursued through SP/RP approaches.

DfT Wellbeing Review - Pro-forma
Impact: Noise
Sub-impacts: amenity; health impacts.

TAG Units	A3 Environmental impacts
TAG Data Book	Table A3.1
Underpinning evidence documents	Department for Environment, Food and Rural Affairs (Defra) (2014), Environmental noise: Valuing impacts on: sleep disturbance, annoyance, hypertension, productivity and quiet. https://assets.publishing.service.gov.uk/media/5a7de374e5274a2e8ab44775/environmental-noise-valuing-imapcts-PB14227.pdf Day, B., Bateman, I. & Lake, I. (2007). Beyond implicit prices: recovering theoretically consistent and transferable values for noise avoidance from a hedonic property price model, Environmental and Resource Economics 37, 211–232 (2007). https://doi.org/10.1007/s10640-007-9121-8 Nellthorp, J., Bristow, A.L. & Day, B. (2007). Introducing Willingness-to-pay for Noise Changes into Transport Appraisal: An Application of Benefit Transfer, Transport Reviews, 27:3, 327-353. https://doi.org/10.1080/01441640601062621 Berry, B. & Flindell, I. (2009). Estimating Dose-Response Relationships between Noise Exposure and Human Health Impacts in the UK, Technical Report BEL 2009-02. Shepperton: Berry Environmental Ltd. https://webarchive.nationalarchives.gov.uk/ukgwa/20130403165908/http://archive.defra.gov.uk/environment/quality/noise/igcb/publications/healthreport.htm World Health Organisation (2011). Burden of disease from environmental noise - Quantification of healthy life years lost in Europe. Copenhagen: WHO. https://www.who.int/publications/i/item/9789289002295

Key evidence documents - SWB methods	Lawton, R. and Fujiwara, D. (2016). Living with aircraft noise: Airport proximity, aviation noise and subjective wellbeing in England. Transportation Research Part D: Transport and Environment, 42, pp.104-118. https://www.sciencedirect.com/science/article/pii/S1361920915001959?via=ihub Van Praag, B. and Baarsma, B. (2005). Using Happiness Surveys to Value Intangibles: The Case of Airport Noise, The Economic Journal, Volume 115, Issue 500, January 2005, Pages 224–246, https://doi.org/10.1111/j.1468-0297.2004.00967.x Scott, N., Szydlowska, A., Behzadnejad, F., Malde, J., Lawton, R. and Fujiwara, D. (2020a). Aviation Noise & Subjective Wellbeing, Draft Report to DfT. Simetrica Jacobs. Scott, N., Behzadnejad, F., Lagarde, A., Malde, J., Lawton, R. and Fujiwara, D. (2020b). Valuation of Non-Market Goods in TAG – Guidance Note. Simetrica Jacobs. Sparrow, V. et al (2019). Aviation Noise Impacts White Paper: State of the Science 2019: Aviation Noise Impacts. ICAO. https://www.icao.int/environmental-protection/Documents/ScientificUnderstanding/EnvReport2019-WhitePaper-Noise.pdf
Valuation data	IP: Impact pathway approach (Defra, 2014). Applying value of a DALY (£60,000) to dose-response relationship between noise exposure, 'high annoyance' and 'disability weight' (0.2(0.01..0.12), from WHO (2011) literature review). HP: No longer the basis of TAG values: Housing price data, City of Birmingham, 1997
Valuation methods	IP: Health impact pathway / dose-response HP: Hedonic pricing Note: linked to valuation of a DALY - see also Physical activity and Accidents.
Strengths & weaknesses of current methods	...including capability to capture the full impact. Context and relevance: Transport noise - road, rail and air covered. Scope limited to noise exposure at home. Vibration not covered. Helicopters not well covered (see Sparrow et al, 2019). Night time noise covered by Defra (2014) - all modes - and Scott et al (2020a) for air. Accuracy and confidence intervals: Large datasets and explicit confidence intervals on the values ((IP) meta-analysis with large samples, and (HP) >10,000 property transactions in one year). Confounders controlled for (in (HP and SWB)). Ability to handle hypotheticals/future changes: IP) and HP): Comprehensive coverage across noise levels from 0 to 81dB and above - very good transferability to hypothetical/future applications. Risk around different sound types (e.g. high-pitched sounds from future aerial vehicles). Causality: Impact pathway 'explains' causal chain. Hedonic pricing study (BDL, 2004) uses market segmentation and the second stage of the hedonic method to help identify the demand curve. Transferability: Good across project types, although different noise signatures are a concern , as is vibration (e.g. urban trams). Underlying DW (disability weight) factors may not be based on UK conditions - check. Biases: Impact pathway includes known health, annoyance and sleep disturbance impacts of noise - question whether it includes all perceived impact of noise (double counting could work either way). HP method is limited to effects which people can perceive and hence take into account in property purchases.

	LS approach is not limited by the ability to perceive noise, although clearly it is limited to perceived life satisfaction. Other methodological issues: -
Potential for SWB valuation	Form(s) of wellbeing that could be relevant: All (LS, worthwhile, happiness, anxiety) LS preferred for CBA The existence of evidence: Yes - Van Praag & Baarsma (2005); etc. Key sources in UK today are: Scott et al (2020a); Lawton & Fujiwara (2016) Note: L&F (2016) uses a sample of 240,378 people in England (via APS) matched by postcode to noise map data for 17 airports provided by Defra but ultimately supplied by the airport operators. Of these, 3,545 (check with authors) lived within daytime noise contours >55dB. Note the assessment of this in p65 of Green Book Supplementary Guidance: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/1005388/Wellbeing_guidance_for_appraisal_-_supplementary_Green_Book_guidance.pdf APS wellbeing data is suitable, and is used by L&F (2016) Scott et al (2020a) use Understanding Society data instead: this also contains SF-12 health data. R2s are higher with U.Soc. than APS. Scott et al (2020a) address night-time noise as well as daytime noise. The prospect of developing new evidence: Further research is possible since the datasets are available and there are unresolved questions (below). Risk of double counting: Defra (2014) recognises that annoyance is part of the impact pathway between noise exposure and health impacts. Important that the 'Amenity' impact in Defra (2014) does not double-count the health effects (Direct AMI, Stroke & Dementia). HP & SWB - in each case the perceived impact is measured singly - no obvious potential for double counting. If SWB is treated as an additional impact (GB Supplementary Guidance) there is likelihood of double counting. Opportunity for validation/cross-referencing between valuation methods: Yes, since HP, health impact pathway, SP and LS have all been tested, and other SWB measures could be tested. Spreadsheet analysis [see Table 10 in this report - main text] shows that in Scott et al (2020a), impacts are a different order of magnitude (larger) compared with the 2016 study, or the existing TAG values based on Defra (2014). In Scott et al (2020a), WTA for a noise increase diverges from WTP to avoid (WTA is greater) – this is simply non-linearity not loss aversion, most TAG impacts use a CS metric (between the two), or settle on one metric – authors suggest WTA more relevant for CBA of a welfare loss (p45), but the intervention could equally be noise abatement regulations (a welfare gain). Overall pros and cons relative to preference-based evidence: One key advantage is ability to segment the values by key characteristics (e.g. gender, age) since the data is individual and matched with relevant characteristics, unlike the property datasets used for HP. Dose-response approach has also not allowed segmentation thus far. L&F (2016) use a single coefficient for the wellbeing impact of 1dB change, irrespective of the starting level of noise. This is inconsistent with the findings of the other two methods - see Excel sheet. Would ideally want to explore a variable noise coefficient. L&F (2016) fail to find a value for night-time aircraft noise. This is inconsistent with much of the wider evidence base and the reasons should be considered further. Scott et al (2020a) address these two points, although further concerns appear, specifically: the income coefficient; the WTA/WTP divergence for welfare losses; and the magnitude of the values compared with other evidence. If conducting a future SWB study on noise, there would be an opportunity to analyse road, rail and aircraft noise in the same study, using the research resources more efficiently.

Use of SWB valuation in forecasting and appraisal	How would the valuations be used in practice and would the effort to do so be proportional? Value per 1dB change in noise exposure (by mode, linked to starting level), applied to Δ noise due to the project - as now. How would the SWB measures be linked to transport models? Same as now: transport model -> noise mapping -> noise exposure data (with/without project) -> Δ noise -> multiply by values.
Forecasting tools available	Yes - existing noise modelling and mapping tools.
Segmentation for distributional analysis	SWB data available by: age; sex; disability; ethnicity; index of multiple deprivation; UK country; English regions; local authority (Inclusive Data Taskforce/Measuring National Wellbeing 2022-3). Values not currently segmented. L&F (2016) and Scott et al (2020a) do not segment - would need to interact noise term with segmentation characteristics. Segmentation possible from SWB (and SP) data - not HP (except spatial variables).
Potential to incorporate SWB within TAG	Yes, possibly: in a validation role and/or to allow segmentation Scott et al (2020a) suggests much higher values than other methods - needs careful consideration.