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Giving current and future generations a real voice: a practical method for constructing sustainability viewpoints in transport appraisal

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Decisions to invest in large-scale transport projects typically extend beyond traditional cost-benefit analysis. Multi-criteria analysis methods such as multi-actor multi-criteria analysis (MAMCA) have been proposed to assess wider economic effects and long-term environmental impacts from various stakeholder perspectives. However, there is no standard practice for appraising transport projects against sustainable development objectives. In order to give future generations a voice in decisions that will impact them, this paper extends the MAMCA methodology to make various actors and a "sustainability viewpoint" explicit. A dual-approach method for constructing sustainability viewpoints in transport appraisal is proposed. The method juxtaposes an expert-based approach with a principle-based approach. In the former, sustainability experts are asked to prioritise criteria for project assessment. In the latter, criteria weights are calculated based on sustainability theory ("strong" and "weak" sustainability). Together, these viewpoints are intended to inform decision-making. The appraisal of HS2 Phase I, a high-speed rail project in the UK, is used to demonstrate the proposed method. It is found that all three variants of the sustainability viewpoint result in project preferences that are similar to each other, but different from those of other transport professionals. The paper concludes by arguing for the explicit inclusion and triangulation of sustainability viewpoints in transport appraisal on a multi-actor basis. One practical recommendation from the MAMCA process is the need to hire more transport planners with sustainability experience into government planning agencies.

Keywords: *Sustainability, future generations, indicators, national transport planning, decision support.*

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Introduction

Large-scale transport infrastructure projects involve substantial economic, social, and environmental impacts, affecting both present and future generations. As the process through which projects are prioritised, transport appraisal[5] methods matter greatly (Flyvbjerg, 2014). In the case of transport mega-projects – costing billions of dollars, affecting millions of people, and impacting the environment for decades and centuries to come – the effectiveness of appraisal methods, which should play a key role in decisions to build such infrastructure, matters even more.

Despite the need for methods of analysing and comparing transport intervention measures against a wide range of competing goals – mobility and accessibility, socio-economic and environmental issues, safety and cost control, to name but a few – there currently exists no standard process for appraising transport projects against sustainability objectives, with practices varying widely across countries (Mackie et al., 2013; Hayashi and Morisugi, 2000; Bueno et al., 2015). Indeed, if the sustainability challenges described three decades ago in the Brundtland report (WCED, 1987) are to be addressed for the transport sector, it is imperative that long-term impacts are explicitly incorporated into transport appraisal processes. A recent report by the Future of Humanity Institute at the University of Oxford concludes by recommending nations to "incorporate the interests of future generations into their decision-making frame-works" (Cotton-Barratt et al., 2016).

In order to give future generations a voice in decisions that will impact them, this paper proposes a dual-approach method for constructing a "sustainability viewpoint" in transport appraisal. A sustainability viewpoint (SV) weights transport assessment criteria with sustainability in mind. Both approaches developed in this paper are based on multi-criteria analysis (MCA); however they differ in how they assign weights to the various project assessment criteria. The first is a bottom-up approach in which sustainability experts are asked to prioritise criteria for project assessment, and the second is a top-down approach in which criteria priorities are calculated based on sustainability theory.

The case of HS2 Phase I, a high-speed rail project in the UK, is used to demonstrate the operationalisation of this dual-approach method. The goal of the proposed method is to improve the decision-support process for transport projects by taking the interests of future generations into consideration and making explicit those impacts that are relevant to the long-term future.

The rest of this paper is structured as follows. Section 2 presents the theoretical background for the concept of sustainability and a futures generations' perspective in transport planning. Section 3 describes HS2 Phase I, the high-speed rail project that is used to demonstrate the proposed method. Section 4 describes the proposed method for constructing sustainability viewpoints within the broader context of an MCA appraisal process. Section 5 presents the sustainability viewpoints as applied to the case of HS2, compares them with other assessments, and discusses the usefulness of the dual-approach method. Section 6 concludes and proposes a direction for future research.

[5] Terminology: in the UK, appraisal refers to the analysis of proposed actions (ex-ante), while evaluation refers to how actions have worked out in practice (ex-post) – although they are sometimes used interchangeably (HM Treasury 2011). Project appraisal is understood in this paper as a process including assessment as well as public participation procedures, where assessment refers more specifically to the analysis of impacts (also sometimes called more generally effects). Impacts can be detrimental or beneficial.

1. Theoretical background

1.1 Conceptualising a future generations' perspective

The ethics behind the concept of future generations imply ensuring equal opportunities, both within and between generations, which is an inherent part of sustainable development as defined and conceptualised in detail throughout the Brundtland report (WCED, 1987; see also Langhelle, 1999). Intergenerational justice requires a type of development that would not preclude future generations from meeting their own needs, which as a consequence imposes physical constraints on present generations in order to preserve both renewable and non-renewable resources on one hand and remain within environmental planetary boundaries on the other – this is referred to as the 'safe operating space' for humanity (Rockström et al., 2009; Steffen et al., 2015). In other words, according to Earth systems theory and the laws of thermodynamics, development[6] should preserve the characteristics of the ecosphere, defined as the natural life sustaining systems of the Holocene, the stable geological period which, for the last 10,000 years, has allowed the human species to flourish (Robèrt et al., 2002; Johnston et al., 2007).

Based on this, but also on the potential for human actions to affect the balance of the Holocene for the foreseeable future, the 'long term' is defined as over 100 years and up to 10,000 years. Because shorter-term impacts are essentially invisible to future generations, it can be assumed they would be concerned primarily with those aspects of development that bring long-lasting impacts, positive or negative. Most – but not all – environmental impacts are slow to unfold and therefore fall into that category, as illustrated in Figure 1 below. Therefore taking a future generations viewpoint moves the prioritisation of impacts towards the notion of 'strong sustainability' (see e.g. Connelly, 2007).

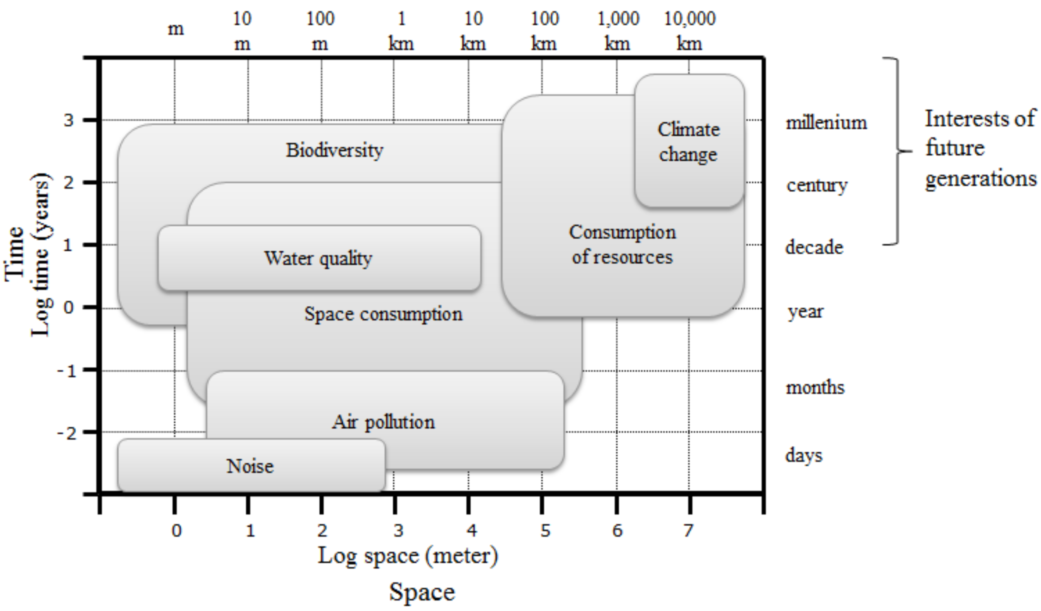

Figure 1. Environmental impacts illustrated using Holling's log-time and log-space graphical hierarchy: the interests of future generations are primarily long-term (Holling, 2001).

[6] On development, the universally endorsed Brundtland report of 1987 mentions the "essential needs of the world's poor, to which overriding priority should be given" over the needs of the rich to sustain their way of life or to further improve their general well-being (chap 2 para 1). The report makes clear that the latter should not come at the cost of ecological integrity. In other words, once basic and fundamental human needs are met, the priority in terms of responsibility shifts to sustaining the integrity of environmental systems before pursuing further development or economic growth, and such development should take place only "within the bounds of the ecologically possible" (chap 2 para 5).

Prioritising the long-term future contrasts with conventional transport assessment such as cost-benefit analysis (CBA), where future impacts are discounted to a fraction of their value – and gain little weight in the present value calculation. First, the time horizon in such assessments is usually limited to the useful life of a project. In the case of HS2, the appraisal process considered the construction period and a 60-year operation period, with some impacts such as land use and carbon being considered up to 120 years. But discounting has been criticised for underestimating the importance of future generations (van Wee, 2013). For example, using the declining long-term discount rates from the UK Green Book, which start at 3.5% for the first 30 years, the (monetised) assessment of an impact taking place 30 years in the future would be discounted to 35% of its full effect, and a residual impact 500 years from now would amount to 0.02% of its value in today's terms (see Annex 6 - HM Treasury, 2011). In practice, this means impacts beyond 100 years would weigh less than 5% in the eyes of the generation taking a decision today. While this might arguably represent the (democratically determined) value current generations are willing to attribute to effects and uncertainties of the future, it is questionable whether it adequately incorporates the interests of future generations.

1.2 Operationalising a future generations' perspective

Giving a voice to future generations in practice is problematic, as future generations have neither agency nor identity. It is an abstract concept which, if typified, amounts to "anonymous empty projections, almost completely devoid of individualised content" (Berger and Luckmann, 1966, p48). Furthermore, because future generations' existence depends on previous generations' actions, they may not come into existence at all, thereby further weakening the argument for giving them much voice at all. It is also this uncertainty that discount factors represent. While the use of discounting is practical, it lacks a mechanism to account for critical thresholds.

One prominent source of guidance for operationalising the concept of a future generations' perspective comes from John Rawls's Theory of Justice (Rawls, 2001). Applying the 'veil of ignorance', Rawls asks that decisions be taken with the perspective of being blind to which generation one belongs to, now or at any time in the long-term future. In other words, this would require asking whether future generations mandate – or at least agree – that a particular infrastructure project be approved. For this Rawls proposes a principle which should be agreeable to all people and all generations: "Thus the correct principle is that which the members of any generation (and so all generations) would adopt as the one their generation is to follow and as the principle they would want preceding generations to have followed (and later generations to follow), no matter how far back (or forward) in time" (Rawls, 2001, p160). Rawls's Just Savings Principle (JSP) is based on the idea that people of any generation leave to subsequent generations at least the equivalent of what they received from previous generations. Similar to the 'safe operating space' concept from Earth sciences, applying Rawls's JSP would effectively sustain the common goods needed for upholding the future community. This paper uses Rawls's theory as a starting point for considering a future generations' viewpoint (for more on applying sustainable development and Rawls's theory to transport and decision-making see discussion and critique in Hall, 2006, section 2.2.1; see also Pereira et al., 2017 and Nahmias-Biran el al., 2017 for more recent reviews).

The three dimensions of social, economic and environmental sustainability have become a de-facto starting point for conceptualising and assessing sustainable development in transport and elsewhere (Moldan et al., 2012). The social and environmental dimensions have received growing attention within corporate social responsibility initiatives in parallel to Elkington's coining of the term 'triple bottom line' (Elkington, 1997). Social cost theory provides the basis for categorising impacts, distinguishing between internal costs and benefits (direct project impacts) and external costs and benefits (indirect impacts or externalities). The latter can then subdivided into societal impacts and environmental impacts, resulting in the following three categories of appraisal criteria: direct project impacts (internal costs and benefits); indirect societal impacts (externalities – people); and environmental impacts (externalities – planet).

1.3 Sustainability in transport project assessment

There is a rich and growing body of literature on tools and methods for the assessment of sustainability in transport, such as CBA, MCA, life-cycle assessments, and indicator-based sustainability rating systems (see Bueno et al, 2015 for a recent review). Several researchers have also proposed the idea of a 'strong sustainability' viewpoint. For example, Jeppesen (2009) discusses the concept of 'sustainability advocates' concerning multi-methodology approaches to decision-making for sustainable transport planning, with the specific purpose of making the concept of sustainability explicit in transport planning. Joumard and Nicolas (2010) implement a weighting system in which the two irreversible impacts of 'greenhouse effect' and 'biodiversity'[7] are isolated from other economic, social and environmental indicators, so that a project would be considered 'sustainable' only if all five aspects improve independently of each other (and therefore addressing the issue of discounting critical environmental capital mentioned above). Holden et al. (2013) suggest a 'sustainable transport space' based on a review of the Brundtland report where safeguarding long-term ecological sustainability, satisfying basic human needs, and promoting intra- and intergenerational equity are given priority over, for example, economic growth. Finally, Pryn et al. (2015) further elaborate on the practical implementation of a future generations' advocate using MCA tools to compute an assessment in line with the sustainability principles described above and to compare that assessment with various other stakeholder perspectives.

Within the appraisal literature, one of the methods that has evolved out of MCA is multi-actor multi-criteria analysis (MAMCA), which emphasises the inclusion of multiple viewpoints not just through the incorporation of multiple criteria but through the involvement of multiple actors (Macharis et al., 2009; Macharis and Bernardini 2015). Gudmundsson et al. (2016) similarly advocate for users and organisations to be jointly involved in developing assessment frameworks. The inclusive nature of MAMCA opens up this possibility of incorporating diverse viewpoints into transport appraisal – including 'future generations' as an additional 'actor'.

2. Case Description

HS2 Phase I is used to demonstrate the dual-approach method. HS2 is a proposed[8] high-speed rail (HSR) network to connect major cities in Britain, with Phase I connecting London and Birmingham in the West Midlands (221 km) and Phase II extending the network to Manchester, Sheffield and Leeds (for a total of 530 km of high-speed rail lines). Construction of the first phase is to begin in 2017 with an indicated opening date of 2026. Completion of the full network is expected in 2033.

HSR in general and HS2 Phase I in particular provide an excellent opportunity to examine sustainability in the context of transport appraisal because of the uncertainties and long-term effects of such mega-projects (Flyvbjerg, 2014). As a transport project, HSR potentially alters the space-time geography significantly, affecting all aspects of sustainability. Economically, the wider economic benefits that HS2 is expected to generate may be exaggerated by conventional CBA accounting methods[9]. For example, it is unclear how much of the generated growth would in fact

[7] The updated concept of planetary boundaries later confirmed this hierarchy by recognising climate change and biodiversity integrity as 'core' planetary boundaries (Steffen et al., 2015).
[8] Phase I of the HS2 project was passed into law in February 2017 (The High Speed Rail (London-West Midlands) Act).
[9] Recent research has shown that this difficulty undermined the validity of the initial cost-benefit analysis conducted for HS2 (Dudley and Banister, 2015)

be a spatial reorganisation of economic activity (Castles et al., 2011; Graham and Melo, 2012). Socially, HS2 is shown to bring mixed results in terms of transport justice. For example, in some locations, HS2 is exacerbating rather than resolving regional disparities in accessibility (Givoni, 2006; Vickerman, 2014). There is also ample evidence from France that HSR tends to benefit primarily higher income groups and reinforce the major urban centres[10]. Environmentally, HSR may appear at first glance to be more environment-friendly than, say, road transport projects. However, the assumption that HS2 would benefit the two core planetary boundaries of climate change and biosphere integrity is not so easily demonstrated and depends on numerous factors. For example, HSR alignments may establish new transport corridors in less built areas, which are more likely to disrupt protected areas and biodiversity – a concern of particular significance in the geography of the UK. Tunnelling is effective in addressing this concern, but significantly increases costs, disruption, waste, and embedded carbon associated with construction (Cornet et al., 2017).

The officially stated project goals for HS2 are to "provide sufficient capacity to meet long term demand, and to improve resilience and reliability across the network, and to improve connectivity by delivering better journey times and making travel easier" (HS2 Ltd, 2013c). It is noteworthy that the official goals make no mention of sustainability – even though the project was proposed, appraised, and approved during a period when the UK had sustainable development strategies as well as binding climate goals in place. Indeed, the appraisal process that was applied to HS2 (and even included hundreds of pages of environmental impact analysis) has been criticised for its emphasis on economic growth at the expense of environmental and social impacts (Gudmundsson et al., 2016: chapter 9), for the early decision on design speed which exacerbated biodiversity and climate impacts (Cornet et al., 2017), and for the overall importance that strong narratives played in decision-making (Dudley and Banister, 2015).

A number of projects were proposed as alternatives to HS2 Phase I. Two of these were retained for this case study: both are rail projects, and both are based on real proposals considered at different stages of the HS2 Phase I appraisal process (both alternatives also accept the objectives of HS2 as given and seek to meet those same objectives through alternative rail projects). One is an alternative high-speed rail alignment following an existing transport corridor (the M1 motorway alignment, see HS2 Ltd, 2012). The other is an extended upgrade to the existing West-Coast Main Line. This upgrade would tackle 'bottlenecks' and provide additional capacity mainly through a programme of train lengthening, increased frequency, modernisation of junction designs as well as the provision of additional tracks in some locations (HS2 Ltd, 2013b; Atkins, 2012). Table 1 summarises the key features of each project, and Figure 2 shows a map of the three alignments.

[10] In France, 28% of trips by TGV (Train à Grande Vitesse, HSR in French) are made by the top 10% of the population in terms of income, compared to 50% of trips by conventional trains being made by the lowest three deciles of income. This is compounded by the fact that TGV travellers tend to be residents of larger agglomerations (see Annex no 5 and 6 respectively in Cour des comptes, 2014).

Table 1. Summary of the three project options.

	HS2 Phase I	Alternative 1: **West Coast Main Line upgrade**	Alternative 2: **High Speed Rail along M1 motorway**
Base investment cost	ca. £20 billion (£19.4-21.4bn)	ca. £3 billion (£2.6-3.8bn)	ca. £22 billion (£2.2bn more than HS2 Phase I)
Journey time between London Euston and Birmingham	49 minutes	73 minutes *Currently: 85 minutes*	55 minutes
Maximum speed	250 mph (=400 kph)	140 mph (=225 kph) *Currently: 125mph (=200kph)*	186 mph (=300 kph) *Same as HS1 between London and Paris*
Key features	• New dedicated line from London to Birmingham with no stations in between • Route avoids major population centres by running mostly through rural areas • Route passes through Chilterns Area of Outstanding Natural Beauty (AONB)	• Line passes through and serves many population centres between London and Birmingham • Requires very little additional land • Some disruption of existing service expected during upgrade	• New dedicated line from London to Birmingham with no stations in between • Route passes through or near many population centres • Avoids Chilterns Area of Outstanding Natural Beauty (AONB)

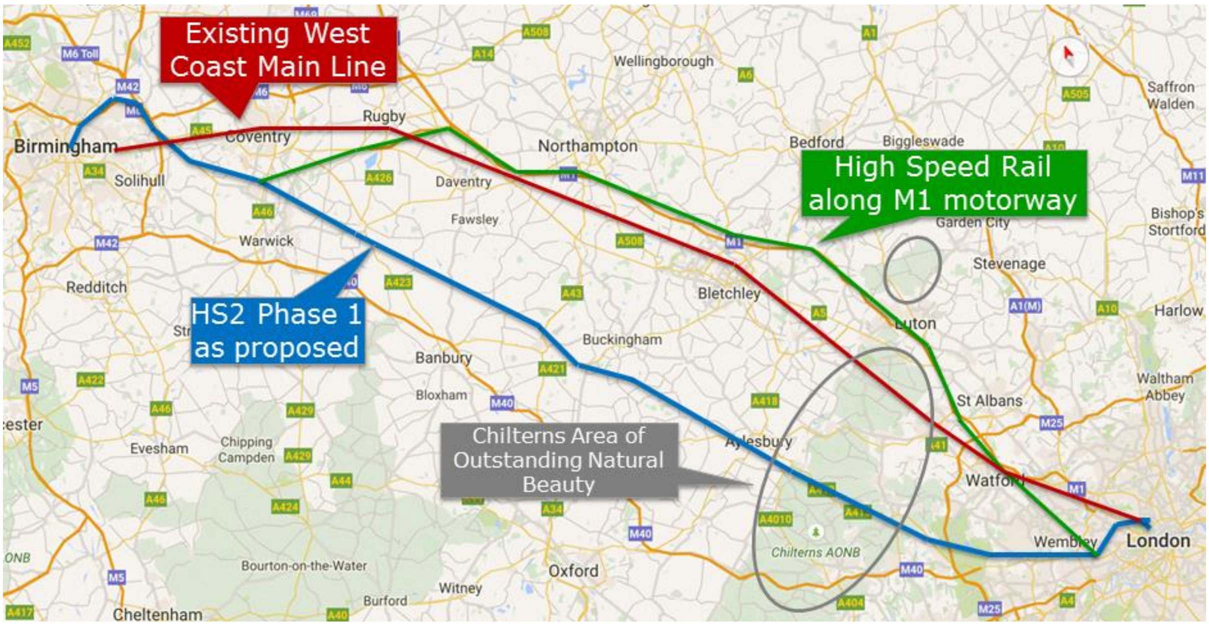

Figure 2. Alignment of the three project options. Map data: Google.

3. Methods

The MCA literature proposes a wide range of techniques to assess impacts that are currently not feasible or practical to quantify in absolute terms (Browne and Ryan 2011; Barfod and Salling 2015). Given a set of project options to be compared, the core MCA process (based on the standard method proposed by von Winterfeldt and Edwards, 1986) consists of four fundamental steps:

1. selecting the assessment criteria (section 4.1);

2. assessing the performance of each project on each criterion (section 4.2);
3. assigning criteria weights (section 4.3);
4. combining the assessments and weights to infer project preferences (section 4.4).

For the first and second steps, this analysis relies on (Barradale and Cornet, 2018; Cornet, 2016), as described below. The third step, assigning criteria weights to represent sustainability viewpoints, is where the central contribution of this paper lies. The fourth step, inferring project preferences, is a standard multiplicative aggregation using the outcomes of the second and third steps. The methods used in steps 3 and 4 are described below, with the results presented in Section 5. The sustainability viewpoints explained in section 4.3 are situated within the MCA process as shown in Figure 3.

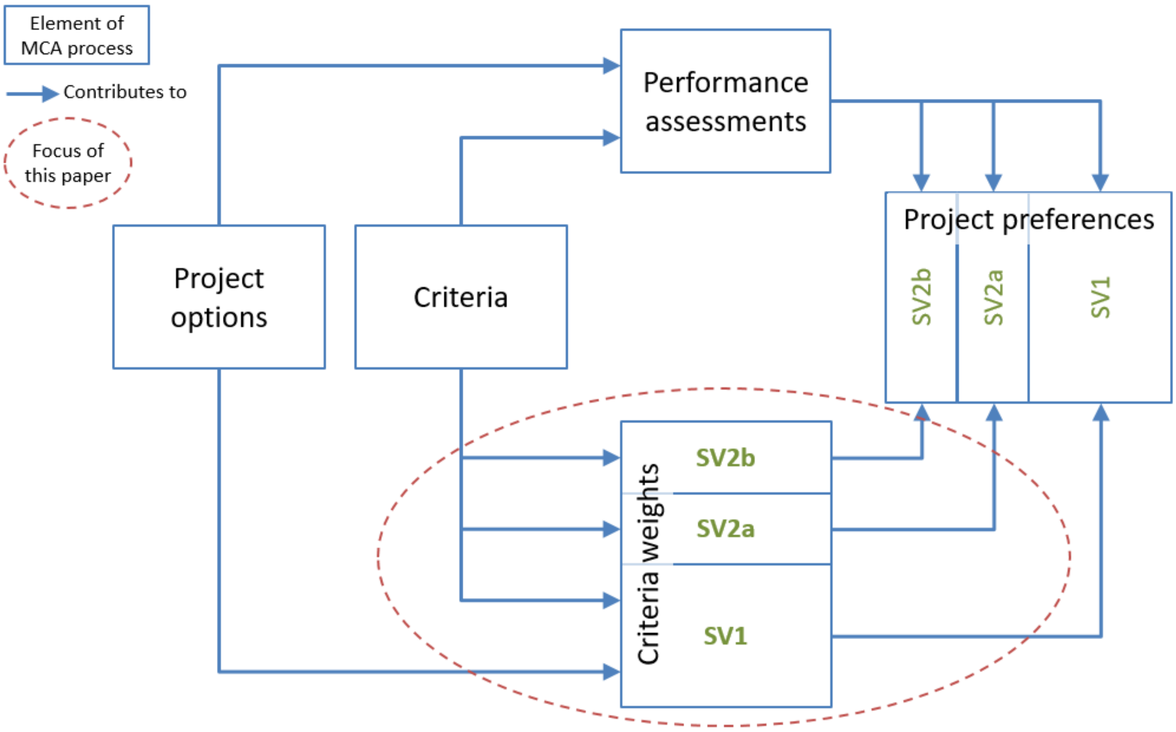

Figure 3. Sustainability Viewpoints (SV) within the MCA process. SV1 = expert-based Sustainability Viewpoint. SV2 = principle-based Sustainability Viewpoint (a = strong sustainability; b = weak sustainability). These viewpoints are represented by criteria weights and are reflected in project preferences.

3.1 *Assessment criteria*

The assessment criteria adopted for this analysis were developed by Barradale and Cornet (2018), using criteria listed in the Transport Analysis Guidance (WebTAG) by the UK government (Department for Transport, 2014) and the impacts assessed in the HS2 appraisal documents (HS2 Ltd, 2013a; Booz & Co. and Temple, 2011) as a starting point. From there, the criteria were expanded and refined using an iterative, mixed deductive/inductive approach to produce a comprehensive and coherent list of criteria for comparing HS2 and its alternatives.

In addition to direct project impacts (those costs and benefits typically considered in transport appraisal), the final list of assessment criteria includes broader impacts on society and the environment (see Table 2). In the detailed descriptions provided in Barradale and Cornet (2018), the criteria are described as “impacts,” suggesting a focus on effects that are important for management and decision-making, thus directly illustrating consequences of human action.

Table 2. List of 28 assessment criteria for HS2 Phase I. Source: (Barradale and Cornet 2018).

Direct project impacts *(internal costs & benefits)*	**Indirect societal impacts** *(externalities - people)*	**Environmental impacts** *(externalities - planet)*
1. Journey cost & affordability	11. Accessibility	20. Agriculture, forestry & soils
2. Journey experience	12. Accidents & safety	21. Air quality
3. Journey reliability & system resilience	13. Community disruption & severance; blight	22. Biodiversity & nature
4. Journey time	14. Equity & distributional effects	23. Carbon footprint
5. Project costs	15. Land use & urban development	24. Material footprint
6. Project delivery risks	16. Landscape, townscape & cultural heritage	25. Noise & vibration
7. Rail capacity for freight	17. Prestige & image	26. Solid waste & disposal
8. Rail capacity for passengers	18. Rail industry growth & innovation	27. Water & land contamination
9. Traffic & transport disruption	19. Regional economic development & regeneration	28. Water resources & flood risk
10. Transport integration & connectivity		

3.2 *Impact assessment*

Impact assessment involves evaluating the expected performance of the options under consideration against the full set of criteria (in this case, of the three projects listed in Table 1 against the 28 criteria listed in Table 2). This assessment can be conducted in a variety of ways (not the subject of this paper), but the aim is always to generate “objective” scores for each project on each criterion (Belton and Stewart, 2002; von Winterfeldt and Edwards, 1986).

For the performance assessments of HS2 phase I and its alternatives, (Cornet, 2016) elicited qualitative judgments from transport professionals and aggregated these using a multiplicative variant of the Analytic Hierarchy Process (AHP) by Lootsma (1992). Because of its cognitive simplicity (reducing complex decisions down to a series of pairwise comparisons), AHP has been shown by many researchers to be a reliable and robust method for capturing judgments in a variety of settings (Vaidya and Kumar, 2006; Macharis and Bernardini, 2015). The results for this type of assessment are computed separately for each criterion (using the geometric mean of all pairwise comparisons involving that criterion) and are expressed in terms of relative project performance.

The transport planners and experts who conducted the performance assessments for this case consisted of 33 professionals, both practitioners and researchers, representing a wide range of expertise and employed in all sectors (public, private, non-profit, academic). Most respondents were from the UK, but some from other parts of Europe who were involved with HS2 were also included. The assessments were done individually, with the final performance assessments (Figure 4) representing an average of the assessments by these 33 individuals. Each bar in the graph shows the expected performance of the three projects relative to each other on one criterion.

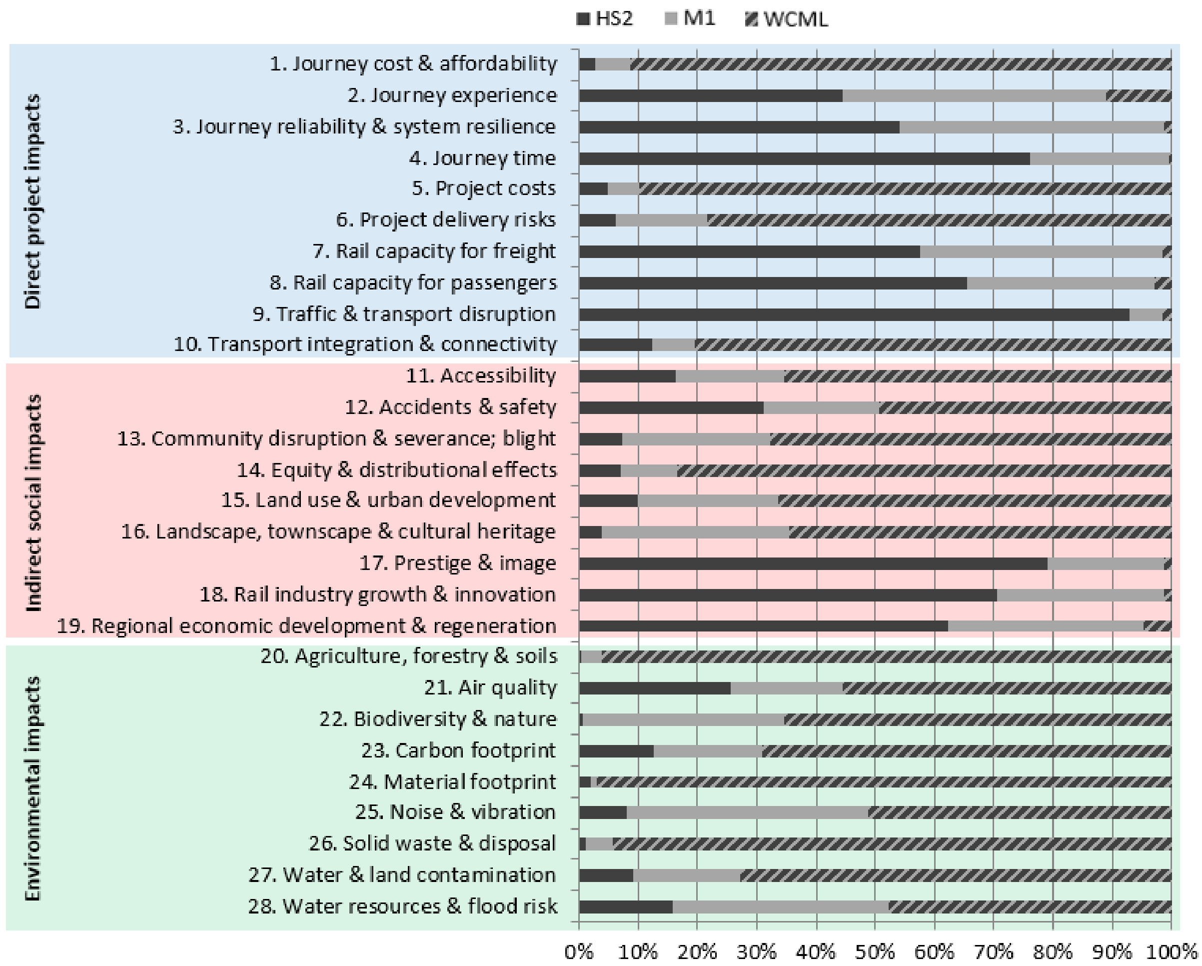

Figure 4. Project performance assessment results for 28 criteria, based on input from 33 transport experts who provided 202 robust assessments (33% consistency threshold). The bars show relative project performance for each criterion. Source: Cornet (2016).

As might be expected, the "best" and "worst" projects vary from criterion to criterion. Figure 4 shows that taking into account only direct project impacts would give an overall preference for HS2, whereas indirect societal impacts indicate no clear preference, and an environment-only perspective would yield a very strong preference for WCML and against HS2. Of particular interest is that HS2 outperforms its alternatives on most of the official project objectives (see HS2 Ltd, 2013c). For example, HS2 was shown to perform significantly better than it alternatives on journey time, passenger capacity, freight capacity, reliability, and reduced traffic & transport disruption – all direct project impacts. On only one of the official project goals, transport integration & connectivity, was HS2 assessed as performing poorly compared to the WCML upgrade option. On the other hand, the M1 alignment and especially the WCML upgrade outperformed HS2 Phase I on almost all environmental criteria[11,12]. HS2 Phase I performance was

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[11] This assessment confirms the concern raised by the House of Commons environmental committee report regarding HS2 Phase I's poor performance on biodiversity & nature (House of Commons Environmental Audit Committee 2014).

[12] Carbon footprint deserves additional explanation because climate change is often considered to be one of the most significant risks to future generations. It is noteworthy that the projects differ so substantially in terms of their expected carbon footprint, even though all three are rail projects and thus ought to perform similarly in terms of carbon emissions during operation and possibly even in terms of the potential for modal shift. Respondents explained this assessment to be due to the much higher footprint of embedded carbon associated

also found to be poor on a number of societal criteria, such as accessibility, land use, landscape, and equity & distributional effects.

Impact assessment is central to appraisal outcomes; however, as the project performance results in Figure 4 show, impact assessment on its own does not point to clear winners and losers. It depends on which criteria are selected as the basis for decision-making and what weights are assigned to those criteria.

3.3 *Criteria weights*

The process of assigning criteria weights – whether based on standard formulas and impact valuations (CBA) or on the opinions and priorities of transport professionals (MCA) – includes a certain level of subjectivity, and the resulting criteria weights naturally inherit this. MCA-based approaches such as MAMCA seek to capture a range of expert knowledge, thereby ensuring the output incorporates multiple perspectives. Different viewpoints are represented by different criteria weights.

Sustainability viewpoints (SV) assign criteria weights with sustainability in mind. This paper's bottom-up-top-down method for constructing SVs juxtaposes an expert-based SV with a principle-based SV. This method is demonstrated using the performance assessments described above; however, it does not depend on the specific assessment process used. Importantly, this method for constructing SVs can be applied regardless of how impact assessment is done.

Expert-based sustainability viewpoint (SV1)

The primary (bottom-up) approach for constructing an SV is to ask sustainability experts to prioritise the criteria according to their perception of relevance and importance to decision-making in the context of the projects under consideration.

For the purpose of identifying transport professionals with sustainability expertise, respondents were asked questions[13] about their professional background and experience, including:

- educational background in environmental studies;
- area(s) of analysis within transport planning and appraisal (e.g., social and environmental impacts);
- level of analysis of HS2/transport infrastructure (i.e., society-level or project-level).

These questions reflect two aspects of this paper's approach to defining "sustainability expertise." First, "expertise" is based on knowledge and experience, not attitudes and beliefs. Second, multiple paths to acquiring expertise are recognised – not just formal education but also applied experience gained through professional work. The survey questions were developed with this multiplicity in mind and sought to elicit a variety of factors that could be considered indicative of sustainability expertise.

The answer choices for each question are not binary (e.g., does/does not conduct environmental impact analysis), but on a spectrum (e.g., to some extent, to a great extent…). Defining a criterion based on each question therefore involved deciding where the qualifying cut-off should be. Here the objective was to strike a balance between high and low bars – sufficiently high to make sure respondents assigned to this group really do know something about sustainability, but not excluding people whose expertise may not be as definable in formal terms.

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with construction and tunnelling for either HSR option (see also Cornet et al. 2017) – the higher speed of travel becomes more resource intensive and gives higher emissions.

[13] Questions also included background in transportation studies, sector of employment, and other types of experience; listed here are only those questions that relate to "sustainability expertise."

Finally, in deciding how many of these criteria should be necessary vs. sufficient to designate someone a sustainability expert, in order to feel confident that the resulting group of experts were indeed experts requires more than one criterion. On the other hand, requiring all criteria to be met would defeat the idea of "multiple paths" to expertise.

In conclusion, in order to qualify as a "sustainability expert," the respondent had to meet any two of the following three criteria:

1. Has formal education in environmental studies (university degree or university-level coursework)
2. Conducts environmental analysis of HS2/transport infrastructure "to a great extent"
3. Conducts analysis of HS2/transport infrastructure primarily at "society-level (wider economic impacts, social/environmental issues)" rather than "project-level (system design, user benefits, project costs, etc.)"[14]

Using this definition of "sustainability expert" provides a practicable method for identifying the sustainability experts among transport professionals (whether this distinction makes a difference will be covered in Results.)

The weighting process involves two steps. First, from the full list of 28 criteria, respondents were asked to select at minimum 6 criteria they deem contextually relevant (it is this contextual relevance that is responsible for the arrow connecting the "Project options" box and the "SV1 Criteria weights" box in Figure 3)[15]. Second, the respondents were asked to "rate the relative importance of each criterion" they selected by applying direct weights using a sliding scale from 0 to 10.

Principle-based sustainability viewpoint (SV2)

The secondary (top-down) approach for constructing an SV is to assign weights based on sustainability theory in a similar way to that described in Pryn et al. (2015). This principle-based approach has two variants: one representing "strong sustainability" (SV2a) and the other representing "weak sustainability" (SV2b).

The strong viewpoint is inspired by a view of the Earth from a systems' perspective and the laws of thermodynamics as described in section 2.1. It is based on the nested model of sustainability, giving higher priority to the environmental dimension over the social dimension and to the social dimension over the economic dimension. This concept is operationalised by considering the three impact categories as representing these three sustainability dimensions and then using the SMARTER (Simple Multi-Attribute Rating Technique Exploiting Ranks) technique (Goodwin and Wright, 2009) applying rank-order distribution (ROD) weights (Roberts and Goodwin, 2002) as follows: direct impacts (15.3%); indirect societal impacts (32.4%); and environmental impacts (52.3%). See Pryn et al. (2015, Table 1) for discussion of this approach. The technique is very simple in the sense that it requires respondents only to rank the criteria in order of importance, after which predetermined surrogate weights are assigned to the criteria. The ROD weights are in this respect surrogate weights determined on the basis of probability theory and have been found to be a close approximation to weights assigned by more complex techniques (see Roberts and Goodwin (2002) for details).

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[14] These categories are based on the field of economics, which provides a clear distinction between private cost-benefit analysis and social cost-benefit-analysis. The former includes only those costs and benefits that are internalised to the project (essentially user costs and benefits), whereas the latter adds externalities to the equation (external costs and benefits are impacts on society as a whole and on the environment). Although based on the economic concepts of private and social CBA, the questionnaire used the phrases "project-level" and "society-level" analysis in order to be understandable to practitioners of all backgrounds.

[15] Question: "Which criteria do you think should be used for assessing the pros and cons of HS2 Phase I and its alternatives? Please select at minimum 6 criteria from the list below."

For the weak sustainability viewpoint, equal weight (33.3%) is given to each of the three impact categories (based on the Triple-Bottom Line concept which sees the three dimensions of sustainability as equally important and substitutable). For both the strong and weak sustainability viewpoints, the criteria within each category are assigned equal weights. Although ROD weights could also be applied within each category, sensitivity tests show this approach does not affect final results for two reasons: first, because the criteria included in the assessment are all relevant to the case study; and second, because as the number of criteria grows, the weight given to the lowest-ranked criteria becomes marginal (Pryn et al., 2015; Jensen, 2012).

Unlike SV1, there is no relationship between SV2 and the specific projects under consideration (except to the extent that the criteria are developed with the projects in mind). Both SV2a and SV2b assign weights to the criteria without regard to the specific project options.

3.4 Project preferences

Project preference scores are calculated using the multiplicative value function model, with assessment scores for each alternative under each criterion and criteria weights as inputs (Equation 1).

$$V(a) = \prod_{i=1}^{m} [v_i(a)]^{w_i} \tag{1}$$

where V(a) is the project preference score of alternative a; $v_i(a)$ is the assessment score of alternative a under criterion i; w_i is the weight of criterion i; and m is the number of criteria.

4. Results

4.1 Expert-based sustainability viewpoint (SV1)

As described in methods, sustainability experts were selected based on education and professional experience. Out of 33 transport professionals who provided input for this case, 15 met two out of three conditions and thus qualified as sustainability experts. This group consisted of 12 academic transport researchers and 3 NGO members. Sustainability expertise turned out to align closely with sector of employment (see section 5.4 for additional details), although this would not have to be the case, as none of the qualifying conditions involve employment sector. It is particularly significant that none of the transport professionals employed in government/public sector met the conditions for sustainability expert.

The expert-based SV is based on the criteria weights these 15 individuals provided in their responses. This number is considered sufficient to provide confidence in the weighting results, provided that the respondents overall are reasonably well chosen and represent a diversity of expertise and experience. According to Guest (2006), saturation of non-probabilistic data occurs within the first six to 12 interviews.

The criteria weights for the entire group are computed as the arithmetic mean of individuals' weights for each criterion. The results for SV1 are presented in Table 3.

Table 3. Criteria prioritisation for sustainability experts (SV1) and principle-based sustainability viewpoints (SV2a = strong sustainability; SV2b = weak sustainability). Top criteria for SV1 are highlighted in grey.

	No.	Criteria	SV1	SV2a	SV2b
Direct project impacts *(internal costs & benefits)*	1	Journey cost & affordability	4.6%	1.5%	3.3%
	2	Journey experience	0.2%	1.5%	3.3%
	3	Journey reliability & system resilience	2.5%	1.5%	3.3%
	4	Journey time	3.4%	1.5%	3.3%
	5	Project costs	4.8%	1.5%	3.3%
	6	Project delivery risks	1.5%	1.5%	3.3%
	7	Rail capacity for freight	4.8%	1.5%	3.3%
	8	Rail capacity for passengers	9.7%	1.5%	3.3%
	9	Traffic & transport disruption	0.2%	1.5%	3.3%
	10	Transport integration & connectivity	12.2%	1.5%	3.3%
		Total weight for direct project impacts	***44%***	***15.3%***	***33.3%***
Indirect societal impacts *(externalities - people)*	11	Accessibility	15.3%	3.6%	3.7%
	12	Accidents & safety	0.1%	3.6%	3.7%
	13	Community disruption & severance; blight	3.5%	3.6%	3.7%
	14	Equity & distributional effects	3.9%	3.6%	3.7%
	15	Land use & urban development	6.7%	3.6%	3.7%
	16	Landscape, townscape & cultural heritage	2.4%	3.6%	3.7%
	17	Prestige & image	0.0%	3.6%	3.7%
	18	Rail industry growth & innovation	0.1%	3.6%	3.7%
	19	Regional economic development & regeneration	6.9%	3.6%	3.7%
		Total weight for indirect societal impacts	***39%***	***32.4%***	***33.3%***
Environmental impacts *(externalities - planet)*	20	Agriculture, forestry & soils	0.9%	5.8%	3.7%
	21	Air quality	0.2%	5.8%	3.7%
	22	Biodiversity & nature	4.0%	5.8%	3.7%
	23	Carbon footprint	9.0%	5.8%	3.7%
	24	Material footprint	0.5%	5.8%	3.7%
	25	Noise & vibration	1.1%	5.8%	3.7%
	26	Solid waste & disposal	0.3%	5.8%	3.7%
	27	Water & land contamination	0.4%	5.8%	3.7%
	28	Water resources & flood risk	1.1%	5.8%	3.7%
		Total weight for indirect environmental impacts	***17%***	***52.3%***	***33.3%***

4.2 Principle-based sustainability viewpoint (SV2)

Based on sustainability theory, the secondary (top-down) approach for constructing an SV has two variants.

The strong sustainability viewpoint (SV2a) prioritises long-term over short-term impacts by assigning the highest weight (52.3%) to environmental impacts and the lowest weight (15.3%) to direct project impacts, with indirect societal impacts in between, receiving 32.4%. Within each category, every criterion receives equal weight. This results in 1.5% for each direct project impact; 3.6% for each indirect societal impact; and 5.8% for each environmental impact (Table 3).

The weak sustainability viewpoint (SV2b) prioritises the three impact categories equally (33.3% each). As with strong sustainability, within each category, every criterion receives equal weight. Because the number of criteria in each category is similar (10; 9; 9), the criteria end up with similar, but not identical, weights: 3.4% for each direct project impact; 3.7% for each indirect societal and environmental impact (Table 3).

Comparing the different approaches and variants of SV presented in Table 3 shows that the largest difference between SV1 and SV2 is not so much the distribution of weight between the impact categories as it is the high degree of variation among individual criteria within each category. This is a direct result of the prioritisation process: SV1 is constructed by asking sustainability experts to prioritise the criteria in the context of these specific projects, whereas SV2 is “blind” to the particular projects under consideration.

4.3 Project preferences based on SV

To see how sustainability viewpoints translate into project preferences and decision-relevant outcomes, it is necessary to combine the project performance assessments in Figure 4 with the criteria weights in Table 3.

Figure 5 shows the inferred project preferences for SV1, SV2a, and SV2b. All three viewpoints translate into similar project preferences (WCML over M1 and M1 over HS2), but not for all the same reasons.

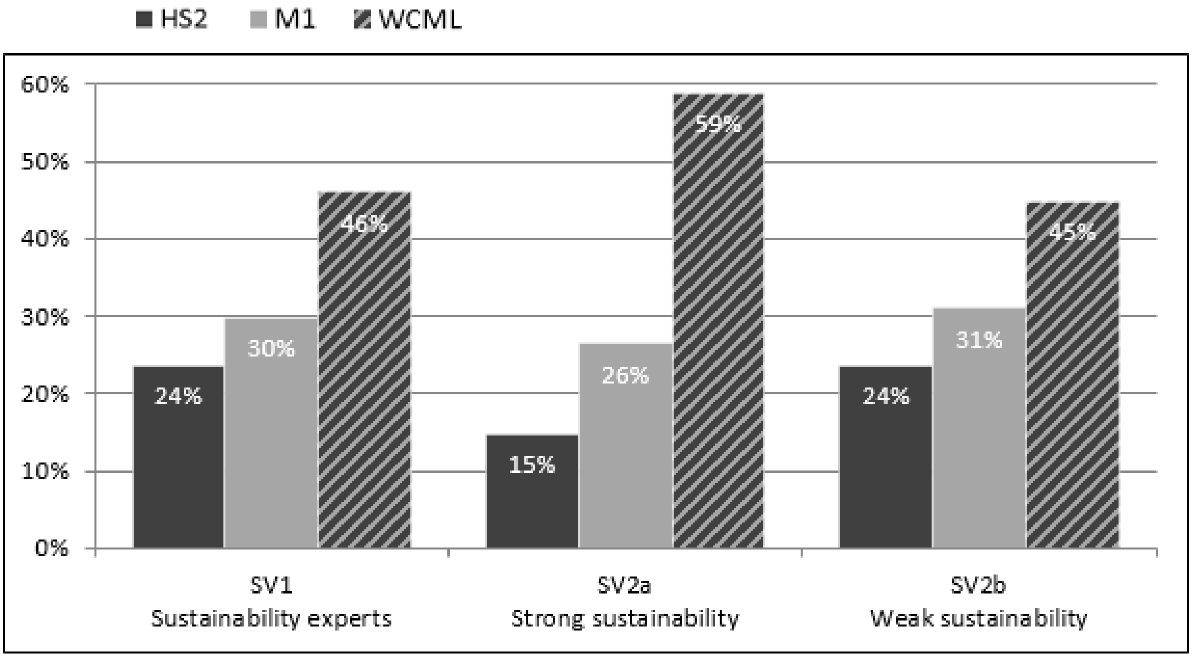

Figure 5. Project preferences based on sustainability viewpoints. SV1 uses criteria prioritisation by sustainability experts; SV2a uses pre-determined criteria weights for strong sustainability; SV2b uses pre-determined criteria weights for weak sustainability.

In the case of sustainability experts (SV1), the preference for the WCML upgrade over both HSR options, with a slight preference for the M1 alignment as a second choice, is attributable in part to the low priority given to journey time and to a greater extent, to the high prioritisations given to transport integration & connectivity, accessibility, and carbon footprint. These three criteria belong to three different impact categories; thus it is not the case that sustainability experts consistently prioritise certain impact categories. This is an important point: issues of concern from a sustainability viewpoint may well be found outside the environmental category used in conventional appraisals.

Since SV2, by definition, prioritises all criteria within each category equally, project preferences for SV2, though comparable to those for SV1, arise from different factors. Given the strong performance of WCML on all environmental criteria (Figure 4), the strong sustainability viewpoint, with its high weighting of environmental criteria, unsurprisingly shows a strong preference for the WCML upgrade over both HSR options. However, even the M1 alignment is significantly preferred over the HS2 Phase I alignment under strong sustainability. From the weak sustainability viewpoint of balancing the three impact categories, the preferences are the same as for strong sustainability, albeit less pronounced.

It is significant that despite the different criteria weights assigned to SV1, SV2a and SV2b (Table 3), the corresponding project preferences are nonetheless quite similar (Figure 5), suggesting that triangulation is successful.

4.4 *SV in comparison with other viewpoints*

As described above, 15 of the 33 transport professionals participating in the study qualified as sustainability experts. Of the remaining 18, eight were employed in government/public sector, three were employed in the private sector, and seven in academia. The eight public sector employees were designated "government transport professionals," as there was no overlap between those transport professionals employed in the public sector and those who qualified as sustainability experts. Too small to justify separate viewpoints, the three transport professionals employed in private sector and the seven in academia were grouped together as "other transport professionals."

Figure 6 juxtaposes the criteria prioritisations by sustainability experts (SV1), government transport professionals, and other transport professionals. The data for sustainability experts are taken from Table 3, column 1. Here, the data for all three groups are presented graphically as radial plots. Each graph has 28 axes (one for each criterion) measured in percentage points. The more weight assigned to a given criterion, the further its data point is plotted from the origin. More important criteria (as prioritised by each group) are the peaks in the spider graph, and less important criteria are the troughs. The graphs not only show the results for individual criteria, but, because they are grouped by impact category, also provide an overview of the relative importance of each category. For example, government transport professionals assigned far more weight to direct project impacts than to environmental impacts, whereas sustainability experts were (relatively) more balanced in their prioritisation of the three categories. The project preferences corresponding to each group's criteria prioritisations are shown in Figure 7.

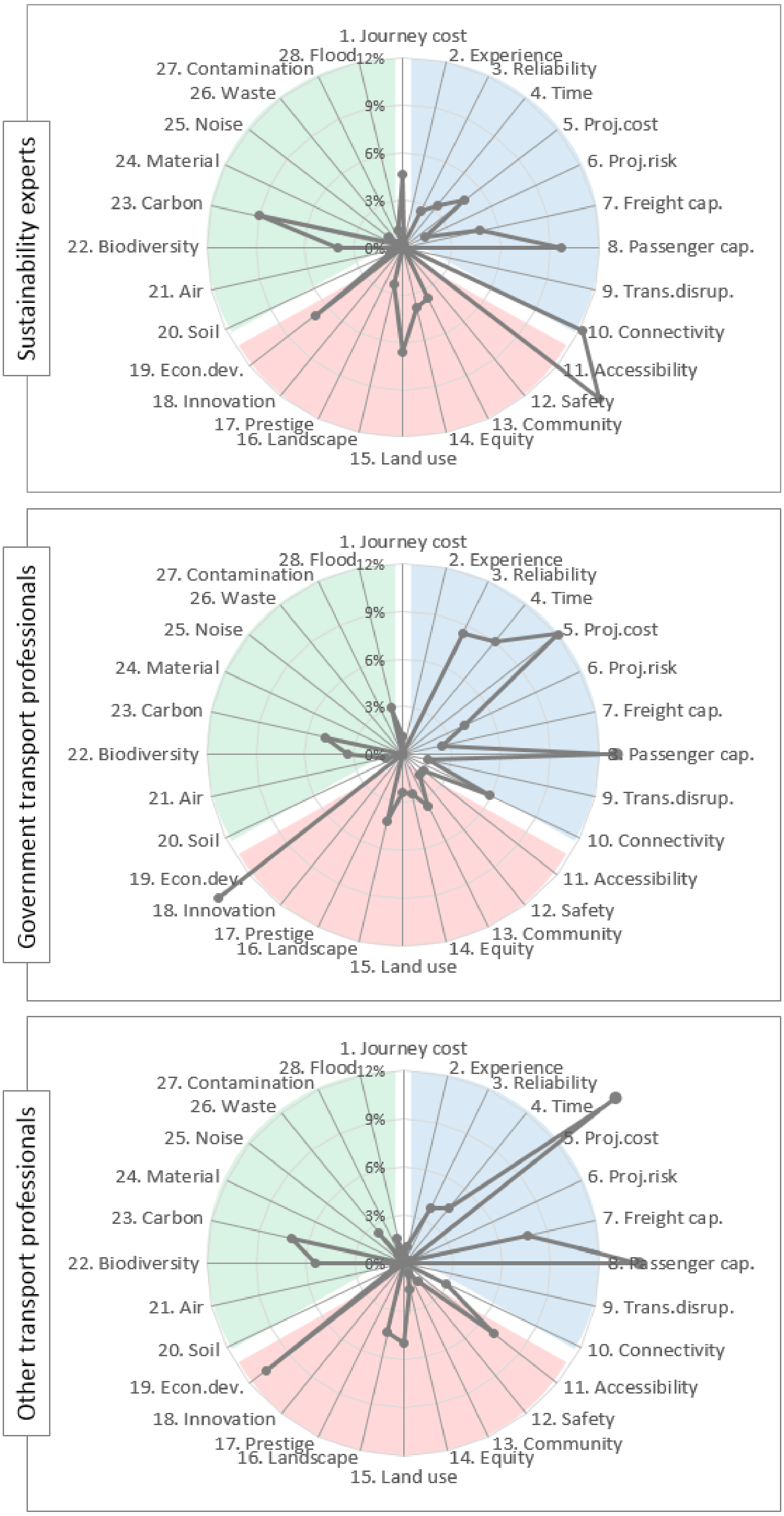

Figure 6. *Radial plot of criteria weights for each group of transport professionals. Each axis shows the percentage weight assigned to one criterion, adding up to 100% for all 28. Blue = direct project impacts. Red = indirect societal impacts. Green = environmental impacts.*

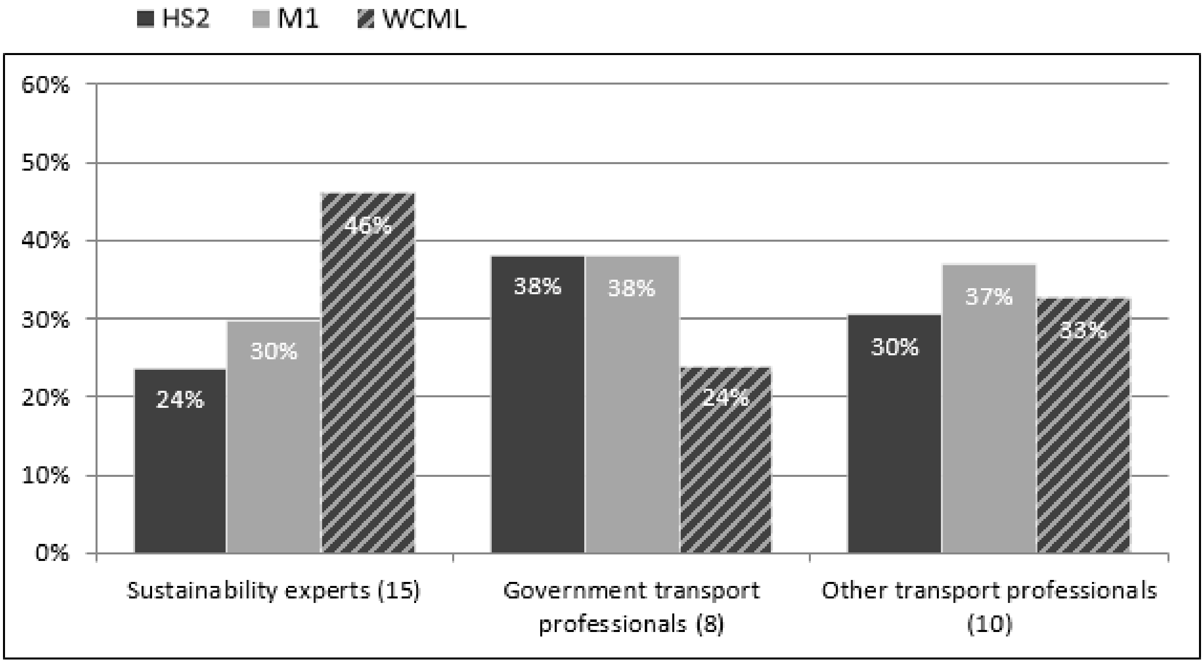

Figure 7. Project preferences for transport professionals. (#) = number of respondents in each group.

As Figure 7 shows, project preferences are most pronounced for sustainability experts, whose priorities translate into a strong preference for WCML. In contrast, government transport professionals favour a high-speed rail solution, but they are ambivalent regarding alignment: the proposed HS2 alignment and the M1 motorway corridor are equally preferred. The main reason for favouring the HSR options is the high prioritisation given to regional economic development & regeneration, on which both HSR options score highly (Figure 4).

Of the three groups, other transport professionals have the least pronounced project preferences, although they do prefer the M1 alignment over HS2, mostly because of the lower importance given to journey time. They also see the WCML upgrade as a viable alternative to HS2, mostly due to the high prioritisation given to project costs, on which WCML scores very well (Figure 4).

4.5 Sensitivity analysis

As mentioned above, the sustainability expert group includes 12 academic researchers and 3 NGO members. As NGOs have been active in voicing opposition to HS2, in order to address possible concerns that including NGO members among the sustainability experts might skew the sustainability viewpoint towards "vested interests," criteria prioritisations and project preferences were also computed for the 12 sustainable transport researchers without NGOs. Comparing the results for sustainability experts with and without NGOs, the prioritisations were not substantially different, with the top 5 criteria the same for both groups (6th place shifted from land use & urban development to journey cost & affordability). The resulting project preferences do not change substantially: 27%; 31%; 42% compared with 24%; 30%; 46% for HS2, M1, WCML respectively.

A second area in which sensitivity analysis can be tested concerns the objectivity and comprehensiveness of the impact assessments used as input to the appraisal. To address this, and although MCA methods do not require this per se, Cornet (2016) adopted a requirement for a minimum number of valid assessments, thereby dropping criteria from the project preference calculations that received too few assessments (below 4). Since 10 criteria received only 2-3 impact assessments, applying a minimum of 4 valid assessments per criterion means basing the project preference calculations on only 18 criteria (8 direct project impacts; 6 indirect societal impacts; 4 environmental impacts). This made essentially no difference to the outcomes for any of the real-people viewpoints. This is explained by the fact that criteria receiving fewer assessments tended to be those deemed less important for decision-making in this context. Whether criteria are formally dropped or whether they are prioritised with very small weights, the effect on project preferences is minimal.

For the virtual SVs based on pre-determined weights, however, it is relevant to note that the results are more affected by dropping criteria. In the case of both strong and weak sustainability, the criteria had to be re-weighted to still give the appropriate percentage weights to each of the impact categories. The effect is greatest for environmental impacts, the category from which the most criteria were dropped. For both SV2a and SV2b, the order of project preferences remains the same as before, but the results are more pronounced: project preferences for SV2a become 8%; 27%; 65% instead of 15%; 26%; 59% for HS2, M1, WCML, respectively; and for SV2b, 14%; 31%; 55% instead of 24%; 31%; 45%.

4.6 Discussion
In the case of HS2 Phase I, all three sustainability viewpoints – though by no means identical in their prioritisations of criteria – nonetheless resulted in similar project preferences (an upgrade of the existing rail network over construction of a new high-speed rail line). It was also noted that HS2 performs best if considered only from the perspective of the official project goals, and it was found that these goals matched the criteria prioritised by government transport professionals in the case study. This finding agrees with Dudley and Banister (2015), who conclude that traditional transport objectives, such as capacity and speed, were overemphasised in the official appraisal of HS2 Phase I as compared with environmental and social objectives.

The expert-based approach (SV1) is considered to be primary for two reasons. First, it allows the specific project context to be taken into consideration as part of the prioritisation process. This makes it possible, for example, to distinguish between impacts that are important for sustainability in general and those that are relevant for the specific projects under consideration. Second, SV1 has the advantage of involving real people (transport professionals) and allowing for reflection and learning, which may be more effective in influencing real-world decision-making.

Although SV1 is the primary approach, it should not be considered "only." SV2 also has some advantages. First, it is not limited by the bounded rationality of the particular experts solicited for input. Second, it provides a partial check on SV1's heavy reliance on the particular set of project options that have been selected for comparison (for example, dropping criteria that may be important even if they don't differentiate the projects[16]). Finally, based on simple calculation rules, SV2 is quicker and easier to construct and can therefore serve as a preliminary sustainability benchmark with which to compare other viewpoints.

The results of this paper suggest that training and experience matter. Those transport professionals whose education or work included environmental analysis prioritised project impacts differently from those who didn't. None of the respondents were asked to prioritise criteria with future generations in mind or in any other particular way (e.g., following Rawls's veil of ignorance); they were simply asked which criteria they think "should be used" for assessing the advantages and disadvantages of HS2 Phase I and its alternatives. It appears, therefore, that simply having a background that includes environmental training and experience is correlated with prioritising impacts as if future generations matter (or at least push the prioritisation in the direction of Rawls's Theory of Justice). Though the differences in criteria

[16] A general implication of the comparative nature of MCA is that the results are inherently relative and cannot tell us whether any of the options being compared are worthwhile. For example, in a case where all options perform very badly on biodiversity – but equally badly – this method would not flag the entire set of options as undesirable. One way to address this issue might be to impose a 'Do-nothing' or 'Do minimum' option as one of the required options to be compared.

prioritisation between sustainability experts and other transport professionals may not be vast, the preferences of SV1 are clearly closer to SV2 than are the preferences of other transport professionals. If this correlation[17] holds true in other cases, then one way to encourage greater emphasis on sustainability in the appraisal of transport projects would be to hire transport professionals who have formal education, training and experience in the areas of environment and sustainability.

5. Conclusions

The key contribution of this paper is the elaboration and demonstration of a dual-approach method for constructing a 'future generations' viewpoint in transport appraisal. Conceptually, the idea of taking the interests of future generations into account is not new; indeed, it is a core component of sustainability as laid out in both the Brundtland and the Future of Humanity Institute reports. Implementing this concept in practice, however, encounters the obvious challenge that future generations cannot be asked directly about their views and interests.

The method proposed in this paper combines two approaches, one expert-based (sustainability viewpoint SV1) and one principle-based (sustainability viewpoints SV2a and SV2b, drawing from 'strong' and 'weak' sustainability theory, respectively). These two approaches complement each other, providing additional context and robustness through triangulation. Together, these three sustainability viewpoints, alongside other stakeholders' viewpoints, are intended to inform decision-making.

A strength of this dual-approach method is that the results are particularly robust when the sustainability viewpoints concur. If and when they differ, on the other hand, further investigation is suggested. Additional research and case studies are needed to determine how often and under what circumstances SV1 and SV2a/b lead to (dis)similar results.

While this paper focuses specifically on the future generations' viewpoint for consideration alongside other viewpoints, it is also important to acknowledge the legitimacy of various 'current generation' stakeholder viewpoints. The approach therefore establishes a sustainability 'benchmark' within an overall process of reflexive planning[18] where differences between stakeholder groups really do matter. This is significant, because current appraisal processes pay little attention to diverse viewpoints.

The results in this paper are based on the input of 33 transport professionals, 15 of whom qualified as sustainability experts. An important point to be made is that none of the government transport professionals surveyed met the criteria of sustainability expert. This is particularly concerning since the government viewpoint was farthest from the sustainability viewpoints. This gap highlights the urgent need for more sustainability-trained policymakers and transport planners to be hired into government agencies – or for qualified sustainability experts to be explicitly included in appraisal processes, as recommended by this paper.

This method cannot establish sustainability or non-sustainability of a project in any absolute sense; as with other MCA methods, the results are inherently comparative. This method does enable a comparison between and among projects and can explain why preferences differ from

[17] This correlation need not be causal. Indeed, priorities could be driven by world view or some other factor (possibly a latent variable). It is sufficient that the desired outcome (priorities that are consistent with sustainability) is correlated with an observable variable (environmental training and experience).

[18] Reflexivity in planning stems from Ulrich Beck's "reflexive modernisation" and is defined as "generating critical knowledge and dialogue that can synthesise the perspectives of multiple actors in a common understanding" (Lissandrello and Grin 2011). Reflexive planning is therefore understood as a part of a broader shift towards communicative rationality in planning, where the focus is on "participation and learning, and a reconciliation of different ways of understanding planning opportunities" (Willson 2001).

one stakeholder group to another. In this case, when assessed against a wide range of sustainability criteria from a perspective that values those criteria, HS2 Phase I turned out to be the least sustainable of the three options, which included the two most serious alternatives considered in the current context (an alignment along existing transport corridors and an upgrading of existing infrastructure).

Finally, while this paper argues for the explicit construction of sustainability viewpoints within transport appraisal on a multi-actor basis, it does not prescribe how such viewpoints should be incorporated into transport planning and decision-making. Further work is needed to understand what difference incorporating these viewpoints would make across different transport infrastructure projects, and to determine the extent to which this paper's proposed appraisal process might influence decisions in practice. Empirical evidence from multiple transport infrastructure cases might not only confirm the results of this case study – that such a revised approach would give future generations a greater voice – but perhaps also shift the outcome of decision-making.

Although this paper did not aim to evaluate the effectiveness of various sustainability processes, the method proposed in this paper does have three distinct advantages: 1) it utilises an inclusive, democratic approach that may be more politically acceptable to the public than the current top-down process that obscures whose judgements are being relied upon; 2) it has been developed well beyond the conceptual stage and is described in concrete, how-to steps; and 3) it makes sustainability viewpoints explicit by presenting them side-by-side on equal terms with other viewpoints. Were this approach to be adopted as a standard component of appraisal processes, it might well be effective in supporting a transition towards sustainability. Transport is the key sector where little progress is being made in reducing CO_2 emissions – and a key way to change this is to invest in a different programme of projects.

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