International Transport Forum

Worthwhile Use of Travel Time and Applications in the United Kingdom

Discussion Paper

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Roundtable

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- Stakeholders from various public and private sector organisations across the UK transport sector, who attended workshops at the outset of the study and at the end of the survey design and testing phase.
- Operators of railway stations, "other PT" services, motorway service stations, petrol stations and other areas where interviewers worked.
- Members of the Analytical Challenge Team who reviewed the study, namely Professor Glenn Lyons (University of West of England, United Kingdom), Professor Jonas Eliasson (Royal Institute of Technology, Sweden) and Professor Kay Axhausen (Swiss Federal Institute of Technology).

While the study was guided, monitored and reviewed by the Department, the results reported, findings inferred, and views expressed in the present paper are the responsibility of the authors and not necessarily a statement of the Department's policy or guidance.

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Introduction

As a leading country in transport modelling and appraisal, the United Kingdom has made a significant contribution towards the development and application of methods for valuing the non-market effects of transport infrastructure and policies. Among these effects, the value of travel time savings (VTTS) is usually the largest single component of the monetised benefits of transport infrastructure projects and policies. Furthermore, time-related benefits such as the value of travel time reliability (VTTR) and crowding and congestion relief are conventionally valued as multipliers of the VTTS.

Prior to the most recent study (Arup, ITS Leeds and Accent, 2015a), there had been three waves of national VTTS studies in Britain. First, a series of research studies during the 1960s, the results of which were synthesised and adopted by the Department in appraisal guidance. Second, the MVA, ITS Leeds and TSU Oxford (1987) study, which led to updated guidance. Third, the 1994 study by Accent and Hague Consulting Group (AHCG, 1999), which was re-analysed by ITS Leeds (Mackie et al., 2003) and adopted in the newly (at that time) constituted WebTAG guidance. WebTAG, an acronym for WEB-based Transport Appraisal Guidance, was established as a definitive handbook for developing the economic case for transport investment schemes funded by the UK public purse.

Over the subsequent 15 years, these values were regularly updated by the UK Department for Transport (DfT)[1] for income growth but were not resurveyed. This was despite material changes taking place, not only to income but also to travel costs, demography and the mix of travel by purpose and trip length. Possibly more significant was that the world was changing in other ways: the internet revolution, the quality and comfort of travel, working practices and, perhaps most fundamentally, the ways in which people perceived time spent travelling. These phenomena were beyond the scope of simple updating of historical values in line with income growth.

Against this background, DfT embarked upon a research programme in 2009 to review the theoretical, methodological and evidential basis of WebTAG guidance on VTTS. The Department commissioned the following: scoping and review studies on the valuation of time savings for non-work travel (ITS Leeds, John Bates and DTU, 2010) and for business travel (ITS Leeds, John Bates and KTH, 2013); studies to further understand the uncertainty around non-work values (ITS Leeds and John Bates, 2013); and meta-analysis of non-work values post-1994 (ITS Leeds, Arup and URS, 2013). DfT documented its conclusions from these studies in the DfT (2013) report. Among them was the decision to commission a major research study to re-survey national values of not only VTTS but also VTTR. The Arup, ITS Leeds and Accent consortium won the commercial bidding competition for the contract in June 2014.

The study took place in two phases in the challenging timeframe of 11 months. DfT held an inception meeting with the contracted organisation on 3 June 2014, after which the DfT convened and led a workshop with stakeholders potentially affected by revisions to VTTS guidance. Phase 1 of the study, which took place from June to September 2014, involved the development and testing of methods for undertaking the requisite market research. This phase culminated in an extensive pilot survey conducted in two waves, and the estimation of behavioural values on this dataset using discrete choice modelling methods. Having reviewed the Phase 1 report, and convened a further workshop with stakeholders, the Department took the decision to proceed to Phase 2.

Phase 2 took place from October 2014 to April 2015. Using the methods developed in Phase 1, Phase 2 involved a substantial field survey and detailed modelling to complete estimation of the values of travel time using the collected data. DfT released the final report (Arup, ITS Leeds and Accent, 2015a) after a period of assimilation of the results, along with their own interpretation of the findings and proposals for implementation of the findings in WebTAG (DfT, 2015). DfT then consulted with stakeholders potentially affected by the proposed changes to VTTS. On completion of this consultation (DfT, 2016a), DfT finalised the new proposals on VTTS and announced new WebTAG guidance in July 2016 (DfT, 2016b). This became definitive guidance in March 2017 (DfT, 2017a).

This paper highlights insights and conclusions from the UK experience, including the following:

- the rationale for the investigation, particularly around productive time use and the relationship with VTTS
- the approaches investigated and the reasons for the selected willingness-to-pay (WTP) approach
- the key findings from the 2014-15 study
- the approach to implementation and lessons for other countries
- modelling, forecasting, appraisal and land use policy implications due to distance-based VTTS and potentially time-varying VTTS if the level of time use increases with technologies over time.

United Kingdom's 2014-15 value of travel time savings study: The rationale

The DfT specified the following aims for the 2014-15 research study:

- to provide recommended, up-to-date national average values of in-vehicle travel time savings for business and non-work travel based on primary research using modern, innovative methods
- to investigate the factors that cause variation in the values (e.g. by mode, purpose, income, trip distance or duration, productive use of travel time, etc.) and use this to inform recommended segmentation of the values
- to improve understanding of the uncertainties around the values, including estimating confidence intervals of the recommended values
- to consistently estimate values for other trip characteristics for which values are derived from the values of in-vehicle time savings.

In pursuit of these aims, Arup, ITS Leeds and Accent employed an analysis framework based upon the primary dimensions of trip purpose and mode of travel (see Table 1). Key features of this framework included the following:

- The walk and cycle research included in the initial scope encountered significant methodological challenges. It was eventually reported to DfT separately from the mechanised modes, and with only tentative recommendations. (Arup, ITS Leeds and Accent, 2015b)
- The Department, informed by the scoping studies, directed that VTTS should be valued using WTP methods for both non-work and business travel.

- The latter directive in respect of business reflected the Department's interest in replacing the long-standing Cost Saving Approach (CSA) (e.g. Harrison, 1974) for valuing business travel time savings with WTP – if the evidence base was adequate to support such a change.
- While the direction was to implement WTP methods primarily through stated preference (SP) data, the Department encouraged the use of revealed preference (RP) data as a validation device.
- The Department directed that business travel should be valued from the separate perspectives of employee and employer. With regards to the latter, the employee is effectively spending the business's time and money. It is important, therefore, that the employee reports a WTP representative of his or her employer's interests. While directed to examine business using WTP, the Department specifically excluded the Hensher equation (Hensher, 1977) from the scope.

Table 1. Summary of survey design

<table>
<tr><th rowspan="2">Travel mode</th><th colspan="4">Trip purpose</th><th rowspan="2">SP experiments</th><th rowspan="2">Covariates</th></tr>
<tr><th>Commute</th><th>Other Non-Work</th><th>Employees' Business</th><th>Employers' Business</th></tr>
<tr><td>Car</td><td>SP</td><td>SP</td><td>SP</td><td>SP</td><td>SP1: Time</td><td>Income</td></tr>
<tr><td>Bus</td><td>SP</td><td>SP</td><td>N/A</td><td>N/A</td><td>SP2: Time & Reliability</td><td>Distance/Duration</td></tr>
<tr><td>Rail*</td><td>SP & RP</td><td>SP & RP</td><td>SP & RP</td><td>SP</td><td rowspan="3">SP3: Time & Quality
(e.g. crowding, congestion and other types of time)</td><td>Productive Time</td></tr>
<tr><td>Other PT**</td><td>SP</td><td>SP</td><td>SP</td><td>SP</td><td>Trip Type</td></tr>
<tr><td>Walk & Cycle</td><td>SP</td><td>SP</td><td>N/A</td><td>N/A</td><td>etc.</td></tr>
</table>

Notes: SP = Stated Preference; RP = Revealed Preference; N/A = Deemed inapplicable on the grounds that trip rates are relatively low.
* "Rail" refers to heavy rail.
** "Other PT" refers to other public transport, namely trams, light rail and the London Underground.

Rationale for the investigation into productive time use

The presence of "Covariates" in Table 1 demonstrates a particular interest in the extent to which features of the traveller or trip – such as the traveller's income or the length of the trip – might influence VTTS estimates. Arup, ITS Leeds and Accent conducted an extensive search for factors causing variation in the values, involving a large number of traveller and trip features collected from the SP and RP surveys.

As with other national studies, significant evidence showed that VTTS increased with income. This was prevalent in all mode and purpose segments except for bus and "Other PT" commuting. It also found that VTTS varied with the travel time and cost of the trip. The implication of these results was that VTTS also increased with trip distance, given that travel time and cost are closely related to distance, with the cost sensitivity tending to decline more steeply than the time sensitivity.

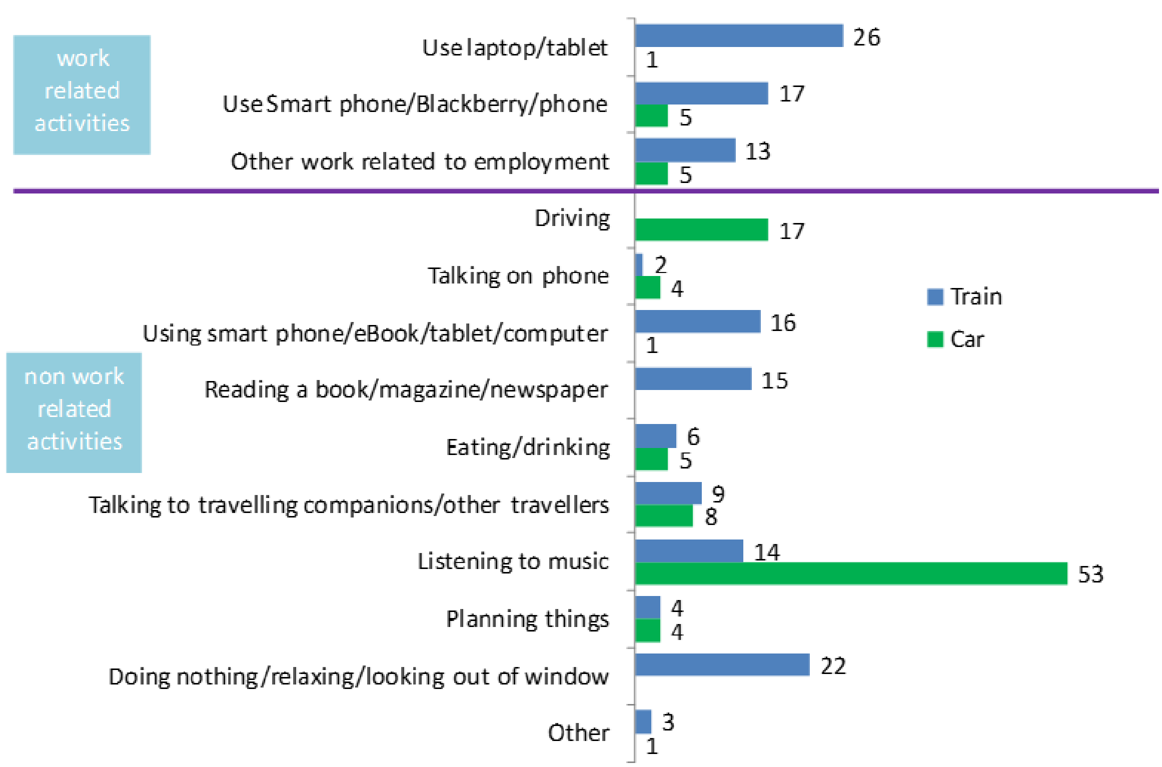
A test of the influence of a wide range of factors on VTTS showed that time use (i.e. the traveller's ability to do something else while travelling, to work or surf the net), geography (i.e. area, urban/rural), current travel conditions (i.e. congestion and crowding) and current road types had little or no impact on VTTS, all else equal. This could indicate that travellers do not necessarily relate the completion of hypothetical choice tasks back to the real-world journey to which these choice tasks relate.

The result relating to time use is of particular interest to the present paper. It is useful, then, to digress slightly and provide additional background concerning the survey approach in this regard. Focussing here upon employees' business travel, since this represents a key segment potentially affected by the productivity of travel time, respondents were reminded of their reported one-way trip time and asked approximately how much of that time was spent undertaking work and non-work related activities.

Figure 1 illustrates that the main activities undertaken by mode were:

- car: listening to music (53 minutes on average) and driving (17 minutes)
- train: using smart phone/eBook/tablet/computer (33 minutes, of which 17 minutes was work related), work-related use of laptop/tablet (26 minutes), doing nothing/relaxing/looking out the window (22 minutes), listening to music (14 minutes) and other job-related work (13 minutes).

Figure 1. Activities undertaken by employees during trip by mode (average minutes)



Fickling et al. (2009) used slightly different categories. They showed the proportion of travellers undertaking work-related activities as follows: preparing for a meeting (38%), making and receiving calls (43%), talking to colleagues or other (12%), use of a laptop (23%), use of a PDA or Blackberry (25%), other work related to employment (36%). By comparison, in the 2014-15 survey, 35% used a laptop, 56% used a Smartphone or Blackberry and 29% did other work related to employment. There has been a notable increase in the use of electronic devices for work-related activities on-train since 2009. It would seem clear that a large proportion of rail travel time is spent on non-work activities, though the caveat remains that more recent research has exposed the propensity for measurement error in self-reporting of time spent on activities (Robles Alejo, 2017).

DfT's long-standing CSA approach to valuing business travel time savings had attracted growing challenge post-1994 because of its inability to reflect the increasing opportunities for people to work while travelling. On the other hand, the WTP approach should in principle reflect how travel time is used, given current travel conditions and opportunities to use that time. While the results indicated that VTTS did not vary with time use, this is not to say that time use is unimportant. It is possible that the results could have been different if the opportunities to use travel time productively had been substantively different for the trips in progress when surveyed. Another possibility is that the importance of time use was not fully captured by the SP exercise, despite the best efforts of the Arup, ITS Leeds and Accent team.

On the deterministic variation of VTTS, Arup/ITS Leeds/Accent found evidence of size and sign effects, although these varied in their nature and strength across modes, choice tasks and attributes (i.e. time and cost). It is conceivable that such effects were an artefact of the SP exercises. However, even if they were not, a given reference point could become less relevant as travellers and travel conditions change over time. Notwithstanding such considerations, appraisal ideally requires reference-free estimates of VTTS. The Arup, ITS Leeds and Accent modelling work sought to identify the prevalence of size and sign effects, before eliciting values which neutralised these effects. For the majority of the aforementioned sources of variation, multipliers of the VTTS were estimated using one category of a given attribute as the base in which case the multiplier was set to a value of one. This is explained later in this paper. This means that the base estimate of the VTTR related to an individual and trip at the base values for these covariates.

Estimating business value of travel time savings and the willingness-to-pay approach

Whereas willingness to pay (WTP) is very much the dominant approach for valuing non-work VTTS, there is less unanimity on the best approach for valuing business VTTS. The rationale behind the approach followed in the 2014-15 study was developed in the course of the ITS Leeds, John Bates and KTH (2013) scoping study – and can be summarised as follows.

Analysing business trip-making is inherently more complex than analysing trips made for non-work purposes where people are making their own travel decisions involving their own time and money. Models require a greater degree of interpretation and judgement. The scoping study expressed reservations regarding the CSA traditionally employed by DfT. It essentially reiterated long-standing and well-rehearsed concerns that not all travel time is unproductive and not all time savings would be converted into productive use to the benefit of the company. In particular, the digital revolution has increased the potential for using travel time productively. Other arguments against the CSA surround difficulties in estimating the value of the marginal productivity of labour (which underpins the approach), the benefits of spending more time at the destination (with a client or at a sales pitch), and the benefits of avoiding overnight accommodation and travel in unsocial hours. However, these effects should be taken into account in a WTP-based valuation, eliciting a reliable representation of what the company would pay.

It might be argued that employers should be the focus of a WTP-based valuation since it is they who will actually be purchasing the time savings. ITS Leeds, John Bates and KTH (2013) suggested surveying employers as to how much they would be prepared to pay to reduce their employees' travel time. In theory, if the CSA is a valid representation of the value of business travel time savings, then the employer should simply express a WTP in line with the CSA. However, in practice, there are recognised difficulties and uncertainties surrounding a valuation approach based on surveying employers. For example, the data collection costs are high, there are challenges involved in identifying the appropriate employer agent, and even then the agent may not be entirely familiar with specific kinds of business trips. Furthermore, such a valuation would require a representative sample of travel-using employers.

A potentially complementary approach is to undertake employee surveys – using either RP or SP approaches – but couched within an awareness of company travel policy. Compared to collecting employers' surveys, obtaining large samples of employees travelling on company business is relatively straightforward. The business scoping study indeed demonstrated that SP studies along these lines tend to be the norm. The concern is whether employees are able to make choices in response to hypothetical scenarios that accurately represent the company's willingness-to-pay or, worse still if they simply represent their *own* willingness-to-pay. If the employee is to be an acceptable proxy for the employer, then that employee needs to respond in accordance with the company's interests as opposed to personal interests. An interesting case here is self-employed business travellers, where one might presume that company and private interests are one-and-the-same and that SP responses would, therefore, reflect what the company would pay.

In the scoping study, ITS Leeds, John Bates and KTH expressed a preference for WTP-based approaches, using different methods for corroborative and interpretive reasons. They proposed that well designed quantitative research, when properly conducted, can provide a coherent story as to how business travel time savings are valued. Better still, it can elicit direct estimates of WTP that lend themselves to comparison against the CSA.

Against this background, the business travel component of the 2014-15 Arup, ITS Leeds and Accent study was informed by three sources of survey evidence, namely employer SP, employee SP, and employee RP. The information collected on income and working hours in the course of the survey also allowed comparison with the CSA. In order to reconcile these different perspectives on business VTTS, two lines of enquiry were pursued, investigating: 1) the degree of similarity between SP-based estimates of VTTS and the CSA; and 2) the degree of consistency between various properties of the VTTS emanating from the different surveys.

Generally speaking, Arup, ITS Leeds and Accent found similar values for the two different SP analyses (employer and employee), and (for some occupational types) similar values for the SP analyses and the CSA. This was particularly so for blue-collar workers, who would be expected to have relatively low productivity while travelling. For briefcase travellers, who are more likely to be productive, SP-based values appeared to be lower than the CSA. Moreover, the degree of similarity between the SP-based VTTS and the CSA was partly dictated by the trip length distribution and did not hold over all distances. The self-employed values were lower than those for employees. This result would seem plausible if the time saved is taken as leisure.

Turning to the properties of the VTTS estimates, the theoretically-driven CSA embodies an income elasticity of one (i.e. implying that VTTS increases in direct proportion to income) and applies a constant unit value to all trips (e.g. irrespective of time, cost, distance, travel conditions, productivity, etc.). By contrast, the SP-based VTTS exhibited income elasticities within the 0.3 to 0.4 range (and significantly less than one) and significant variability by several of the aforementioned dimensions (and notably by distance). Thus, while there was some correspondence between the actual estimates of VTTS from the CSA and SP analyses, this correspondence did not extend to key properties of those estimates.

Table 2. Business value of travel time savings by method of calculation, mode and distance
(2014 perceived prices and values, GBP/hr)

Source/method	Distance	All modes	Car	Bus	Other PT	Rail
Previous WebTAG (2014 prices and values)	All distances	25.47	24.43	15.64	24.72	30.07
CSA estimate from National Travel Survey (NTS) 2010 to 2012 data (2014 prices and values)	All distances	28.27	27.05	13.13	26.33	36.46
Employees' business SP reweighted to NTS 2010-2012 (2014 prices and values)	All distances	18.23	16.74	N/A	8.33	27.61
	<5 miles	5.39	5.27	N/A	8.33	n/a
	5-20 miles	8.84	8.79	N/A	8.28	10.19
	>=20 miles	21.14	19.51	N/A	N/A	28.99
	>=50 miles	24.55	22.53	N/A	N/A	32.56
	>=100 miles	28.62	25.74	N/A	N/A	N/A

Notes: All modes: Distance-weighted, income option 1, SP1 Δt=10.
Tool version 1.1: PT cost is imputed for a trip with a zero cost, and employers paying for EB trips.
WebTAG Other PT is Underground passengers.
WebTAG car EB is weighted average of driver and passenger (vehicle occupancy of 1.2).

Having reconciled the various sources of evidence on business VTTS, Arup, ITS Leeds and Accent recommended that the employee SP survey should be the definitive source of evidence taken forward to the implementation tool (discussed later in this paper). This was because it generated – with some qualifications – similar values to the employer SP survey, but offered a considerably more substantial dataset amenable to generating statistically robust values for a range of trip and traveller segments. Furthermore, the employee dataset was more comparable to the NTS data used as the basis for the sample enumeration. That is to say, the tool applied the choice model from the employee SP to business trips in the NTS to derive an average value over specified segmentations, as shown in Table 2.

The average distance-weighted personal income across the NTS sample was GBP 46 615 (2014 prices and values). This gives a business VTTS in 2014 perceived prices of GBP 28.27 using the CSA (second row, third column). This compares to the CSA-based WebTAG values which have an "All modes" value of GBP 25.47 (first row, third column). Comparing these values to the SP-based values re-weighted for NTS (third row), it can be seen that the VTTS for employees' business across all modes is GBP 18.23. This is 72% of the WebTAG value. There is also substantial variation by mode, with Other PT lowest at GBP 8.33 and Rail highest at GBP 27.61 for the "All distances" values. As proportions of the WebTAG values, these range from 34% (Other PT) to 92% (Rail). Moreover, Table 2 shows that the SP-based values are substantially less at low distances than the previous WebTAG values, but as trip distances increase the SP-based values increase to be close to the previous WebTAG values at long distances (>50 miles).

Key findings from the 2014-15 value of travel time savings study

Returning to a more general perspective across all modes and purposes, the Arup, ITS Leeds and Accent based their recommendations concerning VTTS for use in appraisal on several technical considerations:

- In the short-term, the headline estimate of VTTS should be based on SP1 with Δt = 10.2. In the medium term, pending further development, there could be a case for replacing SP1 with SP3. Arup, ITS Leeds and Accent recognise, however, that each of the three SP experimental trade-offs, namely time/money (SP1), time/money/reliability (SP2), and time/money/quality (SP3), could potentially be used to elicit the headline estimate of VTTS.
- Appraisal values should continue to disaggregate VTTS by trip purpose since there were material differences between the three trip purposes.
- VTTS should continue to be distance-weighted but should be disaggregated into distance bands to reduce the level of approximation between the standard VTTS values and the "real" scheme level VTTS value. Arup, ITS Leeds and Accent recommended further work to determine appropriate distance bands for use in appraisal (discussed later in this paper).
- An "All modes" value should be used for non-work trips due to non-work VTTS reflecting some self-selectivity between modes. Modal values should be used for business, as it was considered that observed differences across modes represented real differences.
- In the case of business, appraisal values should be based on those employees who reported that their employers would be willing to pay for time savings.
- Distinction should be drawn between appraisals of small and medium-sized schemes (referred to as Level 1 in the United Kingdom), and appraisals of major schemes and policies (Level 2) and significant "user pays" initiatives (Level 3). For Level 1 appraisal, standard national values of time can be used. For Level 2, the values may be amended to more accurately reflect local conditions. For Level 3, appraisal values derived from bespoke quality surveys would be appropriate.

For level 1 and 2 appraisals, additional recommendations were made with two different income options. Income option 1 uses the observed variations in income by person and trip to calculate an average value, whereas income option 2 treats all non-work trips as having the same average household income.

- Non-work: for Level 1 appraisals with VTTS distance-banded, as recommended above, income option 2 should be applied. If, however, distance-banding is not implemented – at least in the short-term – income option 1 should be used. For Level 2 appraisals, income option 1 should be applied at the appropriate regional level.
- Business: for Level 1, income option 1 should be applied using national data and applied Level 2 at the appropriate regional level.

Table 3 shows these recommendations for a Level 1 appraisal. This table also presents, for the purpose of comparison, the previous WebTAG values converted to a comparable base (2014 perceived prices).

Table 3. VTTS for a Level 1 appraisal with illustrative distance bands
(2014 perceived prices, GBP/hr)

Source	Distance	Commute	Other non-work	Employees' business				
		All modes	All modes	All modes	Car	Bus	Other PT	Rail
WebTAG	All	7.62	6.77	25.47	24.43	15.64	24.72	30.07
Re-surveyed values	All	11.21	5.12	18.23	16.74	N/A	8.33	27.61
	<20 miles	8.27	3.62	8.31	8.21	N/A		10.11
	20 to 100 miles	12.15	6.49	16.05	15.85	N/A		28.99
	>= 100 miles		9.27	28.62	25.74	N/A		

Notes: Distance weighted, "All" distance values based on income option 1. For distance-banded values, non-work based on income option 2 (household income = GBP 49 684) and business on income option 1. VTTS imputed for PT trips with zero cost, SP1 VTTS, Δt=10, employers paying for EB trips, tool version 1.1.

Recommended multipliers

In addition to the overall VTTS, Arup, ITS Leeds and Accent also made recommendations for adjustments to these values for different types of time. This paper presents them as multipliers. In doing this, account must be taken of the different VTTS coming from the different SP experimental trade-offs (i.e. SP1-3), as well as the general approach of using SP1 values for the overall recommendations about VTTS.

With reference to the SP2 results, the valuations for average time presented in the reliability experiment exceeded the SP1 values by a factor of 1.31 for commute, 2.17 for other non-work, and 1.52 for employees' business. Now it might be argued that by implying the possibility of unreliability, there is some suggestion of (greater) congestion. However, the questionnaire stated that the situation was the same as the reference trip, while the reasons for variation in overall travel time were attributed to "improvements in traffic control", and the variation (unreliability) was attributed to "breakdowns, unplanned roadworks, or general traffic". It is not obvious that this has to imply that SP2 values exceed SP1 values, particularly not at the scale seen for other non-work, where the value was well in excess of that for heavy traffic.

This also presented a problem for the reliability ratio (i.e. relative sensitivity to standard deviation of travel time and mean travel time), as Arup, ITS Leeds and Accent had to decide whether to take the value of the standard deviation relative to the SP2 VTTS or the SP1 VTTS. The former gave values of 0.33 (commuting), 0.42 (business) and 0.35 (other non-work), the latter gave values of 0.43, 0.64 and 0.77 respectively. The former values are low by "received wisdom" (though the evidence base for that is not especially strong), while, at least for other non-work, the SP1-based result is close to the previous WebTAG value of 0.8.

On balance, Arup, ITS Leeds and Accent interpreted these values relative to the SP2 time multiplier, on the grounds of internal consistency within the SP2 experiment. So, for example, the reliability ratio for car was taken from the ratio of the value of travel time to the value of average travel time from SP2 and multiplied by the relevant SP1 VTTS to get an absolute valuation of the standard deviation (Table 4a). The same approach was taken for the early and late multipliers. This is also in line with the way reliability ratios were derived in other work (e.g. Black and Towriss, 1993). However, this was not a strongly-based recommendation, and Arup, ITS Leeds and Accent acknowledged the conundrum of explaining the high SP2 time multiplier. The fact that the SP2 VTTS were rather higher than those for SP1 in the case of car and rail does mean, of course, that the implied valuations of reliability will be lower. Without a clear understanding of the reason for the difference between SP1 and SP2 VTTS, this must be considered an arbitrary judgment.

Table 4a. VTTS multipliers, with SP2 VTTS taken as base

Mode	Multiplier	Commute	Other non-work	Employees' business
Car	Reliability ratio	0.33	0.35	0.42
Bus	Value of early	-2.69	-3.20	N/A
	Value of late	2.88	2.52	N/A
Other PT	Value of early	-2.40	-2.98	-1.66
	Value of late	1.75	2.24	1.95
Rail	Value of early	-1.77	-2.34	-1.55
	Value of late	2.86	3.21	2.76

The remaining multipliers may be considered of lesser importance for reliability, but it is worth noting some additional complications which arose in the case of public transport crowding (SP3). For the public transport modes, Arup, ITS Leeds and Accent opted to align the results with the level of crowding closest to the SP1 VTTS. For bus and other public transport, this corresponds to the level "A few seats free but had to sit next to someone/could not sit with people travelling with. Some standing" (Table 4b). For rail, however, it corresponds to a load factor of 100% (i.e. "all seats taken but no standing" (Table 4c).

Table 4b. VTTS multipliers, with SP3 VTTS for "A few seats free but had to sit next to someone/could not sit with people travelling with. Some standing." taken as base

Mode	Multiplier	Commute	Other non-work	Employees' business
Bus	Plenty of seats free and did not have to sit next to anyone.	0.85	0.83	N/A
	A few seats free but had to sit next to someone/ could not sit with people travelling with.	0.89	0.84	N/A
	A few seats free but had to sit next to someone/ could not sit with people travelling with. Some standing.	1.00	1.00	N/A
	No seats free – a few others standing.	1.24	1.30	N/A
	No seats free – densely packed.	2.14	2.32	N/A
Other PT	Plenty of seats free and did not have to sit next to anyone.	0.95	1.00	1.00
	A few seats free but had to sit next to someone/could not sit with people travelling with.	0.97	1.00	1.00
	A few seats free but had to sit next to someone/ could not sit with people travelling with. Some standing.	1.00	1.00	1.00
	No seats free – a few others standing.	1.13	1.10	1.17
	No seats free – densely packed.	1.70	1.87	1.78

Table 4c. VTTS multipliers, with "seated 100% load" taken as base

Mode	Multiplier	Commute	Other non-work	Employees' business
Rail	seated 50% load	0.73	0.72	0.75
	seated 75% load	0.79	0.72	0.76
	seated 100% load	1.00	1.00	1.00
	seated one passenger per m2	1.09	1.14	1.13
	seated three passengers per m2	1.31	1.39	1.36
	standing 0.5 passengers per m2	1.16	1.21	1.29
	standing one passenger per m2	1.19	1.27	1.38
	standing two passengers per m2	1.32	1.57	1.56
	standing three passengers per m2	1.57	1.79	1.61
	standing four passengers per m2	1.86	2.17	2.03

Turning to the congested values for car, in all cases the SP1 VTTS fell inside the range between the light and heavy traffic values from SP3, though Arup, ITS Leeds and Accent acknowledged the difficulty of justifying this apart from the commuting case. Since, in any case, these ratios were considered to be only indicative of the possible impact of congestion, Arup, ITS Leeds and Accent divided the SP3 values for the three levels by the SP1 VTTS to get the multipliers in Table 4d.

Table 4d. VTTS multipliers, with SP1 VTTS taken as base

Mode	Multiplier	Commute	Other non-work	Employees' business
Car	Free-flow	0.51	0.47	0.42
	Light traffic	0.72	0.83	0.68
	Heavy traffic	1.37	1.89	1.26
Bus	Value of free-flow	0.99	1.22	N/A
	Value of slow down	1.39	1.36	N/A
	Value of dwell time	0.68	1.57	N/A
	Value of headway	1.68	1.60	N/A

Analysis of the Hensher Equation

Before the 2014-15 Arup, ITS Leeds and Accent study, UK appraisal value of business travel time savings (VBTTS) in WebTAG was based on the CSA, which remains commonplace across most of the developed world. Following the conclusions of the research, WebTAG adopted values based on WTP (as in Table 3 above). However, outside of the core remit of the study, a substantial body of evidence was collected on the Hensher parameters *p*, *q* and *r*. The results from this work can be found in Appendix H of the Phase 2 report (Arup, ITS Leeds and Accent, 2015a). Unfortunately, due to a routing problem in the employee questionnaire, the Hensher parameter SP questions were not asked, and the evidence that follows is therefore restricted to employer SP and employee RP.

The current conventional representation of the Hensher equation was first set out by Fowkes et al. (1986), and can be expressed as follows:

$$VBTTS = (1\text{-}r\text{-}pq)\ MPL + MPF + (1\text{-}r)\ VW + r\ VL$$

where:

r is the proportion of travel time *saved* that is used for leisure

p is the proportion of travel time *saved* that is at the expense of work done while travelling

q is the relative productivity of work done while travelling relative to at the workplace

MPL is the value of the marginal product of labour

MPF is the value of extra output due to reduced (travel) fatigue

VW is the difference between the employee's valuations of contracted work time and travel time

VL is the difference between the employee's valuations of leisure time (i.e. the residual time given the work contract) and travel time

Note that *p* and *r* also give rise to companion parameters *p** and *r**, which relate to the proportion of *total* travel time used to do work, and the proportion of *total* travel time at the expense of leisure, respectively.

Drawing on Wardman et al. (2015), there are two noteworthy reduced forms of the Hensher equation which can be estimated using date from the 2014-15 Arup, ITS Leeds and Accent study. The first of these, so called HE1, was advanced by Fowkes (2001) and assumes that business travellers are, on average, indifferent between business travel time and working at their normal workplace, so that *VW*=0.

HE1: VBTTS = (1-r-pq) MPL + MPF + r VL

The second reduced form, so called HE3, applies where there is equilibrium between the allocation of time to work and leisure, so that *VW*=*VL*.

HE3: VBTTS = (1-r-pq) MPL + MPF + VP

Where *VP*=*VW*=*VL* is the benefit to the employee from reduced business travel time and is independent of whether the time saved is spent at work or on leisure. This paper sets both *VL* in HE1 and *VP* in HE3 equal to the "other non-work" VTTS from the 2014-15 Arup, ITS Leeds and Accent study, segmented by mode. Strictly speaking, this is an approximation, as the other non-work VTTS refers to the value of reduced leisure (as opposed to business) travel time. The values presented below, therefore implicitly assume that business travel time carries the same disutility as leisure travel time.

Commentary on Hensher parameter analysis

The employers' SP evidence (Table 5a) highlights that the perceived productivity of time (*q*) spent working in car- and rail-based journeys is high. However, the amount of time spent working (*p**) on such journeys is much lower for car journeys. Moreover, outward journeys by rail are much more productive than return journeys. Hence, there is a high expectation by employers that travel time savings will generate benefits to the firm as denoted by the implied VBTTS. It is noteworthy that for car SP, *p** is significantly less than *p*. This could arise from respondents interpreting the SP questionnaire as asking whether the travel time saved would be converted to work (which is effectively measured by 1-*r*), as opposed to whether work would have been done in the travel time saved (which is the correct interpretation of *p*).

Table 5a. Hensher parameter analysis for employer SP survey

Stated Preference (employer survey)	Car		Rail	
	Out	Return	Out	Return
p*	0.07	0.07	0.45	0.33
r*	0.08	0.07	0.19	0.21
p	0.40		0.45	
q	0.92		0.87	
Implied VBTTS HE1*	GBP 20.88	GBP 21.07	GBP 15.48	GBP 18.45
Implied VBTTS HE3*	GBP 25.39	GBP 25.63	GBP 22.52	GBP 25.31
CSA VBTTS	GBP 23.94		GBP 33.06	
WTP VBTTS	GBP 14.05		GBP 21.31	

The employers' RP exercise (Table 5b) was based around operator decisions on specific railway stretches associated with different travel times. Respondents were asked about how they would use the additional travel time (time saved) when using the alternative operator in order to elicit the *p* value. Compared to the SPURT study (Fickling et al., 2009), the *p* reported here is low (i.e. travel time is less productive than under SPURT), hence the HE-implied VBTTS comes out very small, all else equal. In essence, this implies that when taking the other operator (with an associated change in journey time), respondents would hardly do more (or less) work. The values for *q* and *p** are similar to those observed in the employers' SP (rail), and the WTP-based VBTTS estimates are also comparable across SP and RP.

Table 5b. Hensher parameter analysis for employee RP survey

Rail Revealed Preference (employee survey)	Out	Return	
p*	0.5	0.35	
r*	0.25	0.35	
p	0.40		
	Fast	**Slow**	**SPURT**
p	0.16	0.09	0.41
r	0.60	0.56	0.52
q	0.98	1.04	0.97
Implied VBTTS HE1*	GBP 10.18	GBP 11.84	
Implied VBTTS HE3*	GBP 16.69	GBP 17.49	
Implied VBTTS HE1	GBP 12.70	GBP 15.53	GBP 7.05
Implied VBTTS HE3	GBP 16.17	GBP 19.35	GBP 11.21
CSA VBTTS	GBP 26.98		
WTP VBTTS	GBP 20.43		

On the relationship between the average Hensher parameters (p^*, r^*) and their marginal counterparts (p, r), intuitively $r>r^*$ and $p<p^*$. This is on the basis that there is only so much productive work that can be done on a given trip, so at the margin, time savings are more likely to be converted into leisure time. Likewise, at the margin it is less likely that marginal time savings are at the expense of work done while travelling: the time saving does not eat into the productive portion of the journey. In the RP data, these intuitive relationships are borne out. However, p^* from the employee RP is close to p from employer rail SP (which in turn is quite close to p^* from employer SP). This may suggest that while employers believe the proportions of marginal and average business travel time spent working are similar, this is not necessarily borne out by employee behaviour in practice.

Finally, comparing VBTTS across the different approaches, the CSA invariably gives the highest values except for the car employer SP sample, where the high HE values are driven by very low p^*. As expected, the HE3 values are generally higher than the HE1 values, and the HE* values tend to be lower than their HE counterparts (although this is sensitive to (and non-linear in) r). Based on the employer SP, HE3* values exceed their WTP counterparts, whereas for employee RP even the HE3 values are lower than WTP. This is primarily driven by high r, given that the MPL generally greatly exceeds VP, HE3 VBTTS is strongly decreasing in r. Intuitively, where lots of the time saving is devoted to leisure, the VBTTS is low because (given the work contract) a relatively high proportion of business travel time takes place outside of working time and therefore most of the time savings are not reinvested in production.

Approach to implementation and lessons for other countries

The recommended VTTS values for the appraisal of selected aggregations of the travelling population, as previously described, are obtained from an implementation tool. In short, the implementation tool applies sample enumeration combining the estimated choice models derived from an imperfectly representative sample of travellers with the characteristics of a representative sample of travellers for purposes of establishing recommended values for appraisal.

In the 2003 study (Mackie et al., 2003), the only covariates were distance and income, while separate models were derived for the commuting and other non-work purposes (given the adherence to the CSA at that time, the business models were not taken forward to guidance). This meant that representative values could be calculated by providing a matrix of trips for each cell representing a combination of distance and income, applying the formula to each cell, and calculating a weighted average. In the 2014-15 study, by contrast, the scope of the model was much wider in that a) it contained many more covariates, and b) valuations were generated for a number of quantities in addition to travel time, such that a matrix-based approach would have been unwieldy. While the principles are essentially the same, it was more convenient to make use of a sample enumeration approach. This involved the calculation of appropriate valuations (of time, etc.) for each observation in the sample, making use of the relevant covariates, followed by the calculation of weighted averages over the sample to ensure national representativeness.

For each trip in the NTS sample, appraisal valuations were generated using the behavioural valuations that were based on the discrete choice model. This calculation used the same code as that in the model estimation procedure to ensure complete compatibility. In addition, the estimated standard errors were transferred such that each NTS trip generated information about the statistical reliability of its valuations, obviating the need for a special subsequent step to calculate the confidence intervals associated with the recommended values. It was possible to restrict the calculation of the quantity to summations over the NTS sample observations with particular characteristics, whether or not these characteristics were within the set of covariates defining the valuation formula. Separate valuations could then be derived for geographical breakdowns or for income bands, as well as for mode, purpose, etc. The implementation tool was developed using the statistical software "R", which permits the calculation of valuations for different segments and based on a variety of weighting options to provide the Department with maximum flexibility.

The notion of sample enumeration is transferable to all other countries with an equivalent dataset to the NTS. A local survey would need to be conducted, however, to obtain a set of nationally representative choice models and collect average characteristics for non-NTS-based variables with a significant influence in the behavioural models. Notably, the improved SP design approach of the UK VTTS study would need to be adopted in order to identify all the size and sign effects included in the models.

In this way, the implementation tool provides a straightforward framework to compare the VTTS across a variety of segments, such as travel modes, purpose and other trip characteristics. If and when a uniform survey and analysis is implemented across Europe and repeated at regular time intervals, this would allow better identification of differences in the VTTS across countries and over time (ITS Leeds and Arup, 2018).

DfT consultation process

The Department launched a consultation on proposals for updating its WebTAG appraisal and modelling guidance covering values of time (DfT, 2015) in October 2015, following the conclusion of the primary research project (Arup, ITS Leeds and Accent, 2015a). This covered a wide range of changes, including:

- updated VTTS for use in appraisal across all modes and journey purposes, excluding freight
- segmentation of business values of time into three discrete distance bands (0-50km, 50-100km and 100+km), by mode (Figure 2)
- a revised reliability ratio of 0.4 (down from 0.8), which applies for car travel only
- a revised wait time multiplier of 2.0 (down from 2.5)
- a revised late time multiplier for non-rail public transport of 2.4 (down from 3.0), in line with the revised wait time multiplier.

These changes were generally well-received by stakeholders (DfT, 2016a), with the exception of the distance banding for business values. Stakeholders felt that the large differences in values between bands could generate undesirable bias in the appraisal of schemes near a band threshold, potentially creating unpredictable "cliff-edge" effects were the values to be included in transport modelling. DfT responded to these criticisms by further developing the distance-based business values. The result was the following three-tier hierarchy of approaches in its appraisal guidance, which also met with certain scheme promoters' preference for simple and proportionate appraisal tools:

1. The development of a continuous valuation function, which was implemented in the DfT's official cost-benefit analysis software, TUBA (see Figure 3 for car and Figure 4 for rail).
2. Adjustment of the three distance bands developed for the consultation into four distance bands: 0-50km, 50-100km, 100-200km, 200km+.

3. In the event that the above two approaches were infeasible or disproportionate to the need, the application of simple distance-weighted average VTTS by mode.

Figure 2. Business values of time by mode and distance

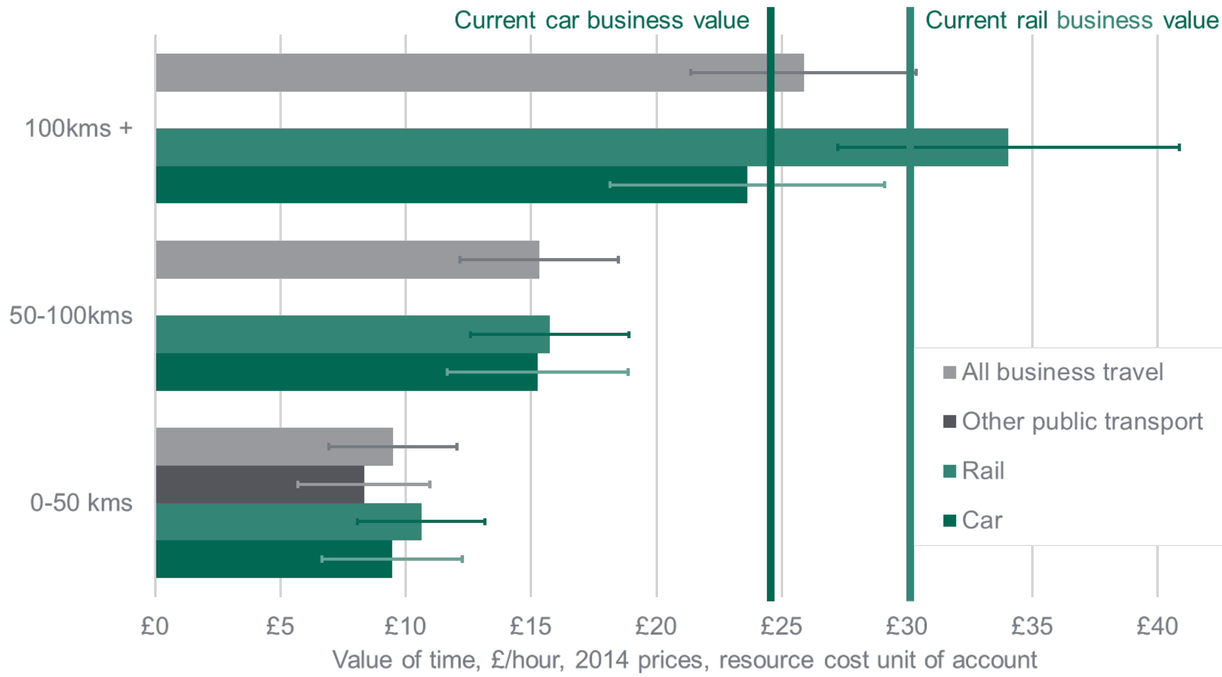


Figure 3. Continuous function versus four bands for employers' business trips by car

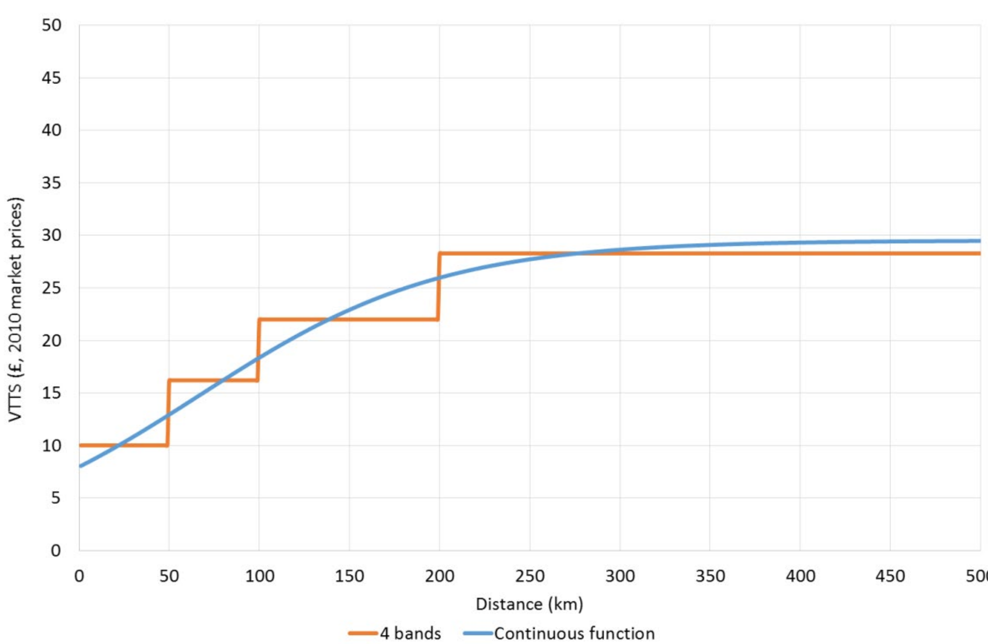
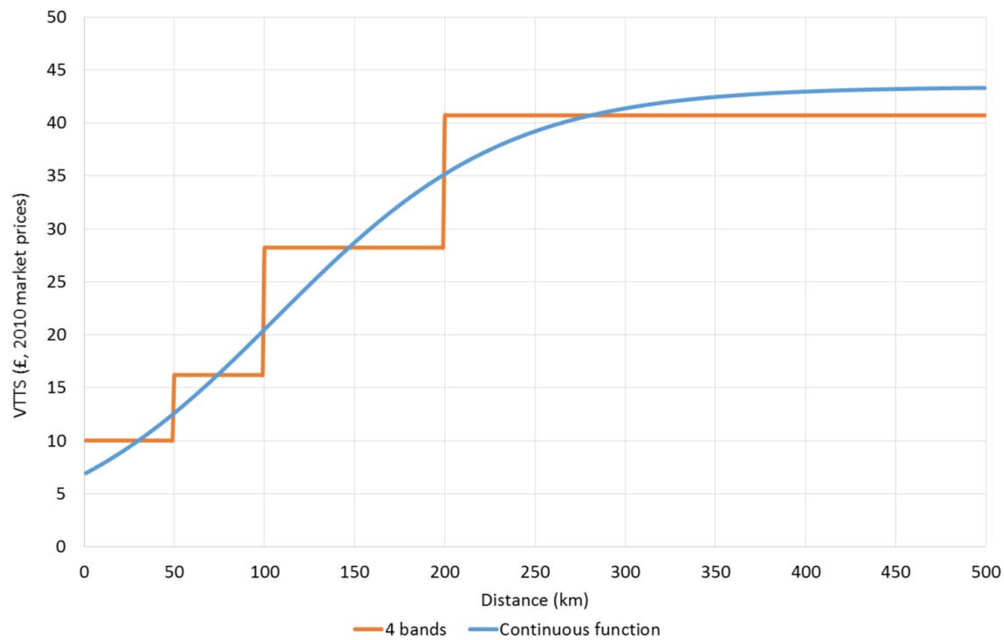


Figure 4. Continuous function versus four bands for employers' business trips by rail



The findings on productive time use were another important dimension of the interpretation of the study's findings in the context of a practical appraisal. A key critique of the Department's previous business values of travel time savings and the assumptions that supported them was that they failed to account for the productive use of travel time, and the increased opportunities to use travel time more productively due to developments in mobile technologies. There are two key attributes of the adopted WTP methods that potentially address this critique. The first is to ask respondents directly on how travel time is used, given current technologies and the ability to use travel time productively. The second is to use such responses to investigate how the use of travel time affects the value of travel time saved.

DfT remained confident, despite Arup, ITS Leeds and Accent's "neutral" finding concerning the effect of productive time use on valuations, that the inclusion of control variables for time use in the reference trips meant that the values estimated accurately reflected the WTP for changes in travel time given current opportunities to use travel time productively. However, the Department also recognised that improvements in technology and changes in business travel behaviour could potentially change these values in the future.

Appraisal issues surrounding modal variation in values

Another striking finding from the primary research was the variation in values across modes. Arup, ITS Leeds and Accent reported an ordering of mode values such that VTTS rail > VTTS car > VTTS bus, which is essentially the reverse of what one would expect based on comfort differentials alone. This is, however, in line with previous empirical studies of VTTS in a UK context (e.g. Mackie et al., 2003). Mackie et al. noted in Sections 7.3 and 8.3 a number of reasons why values might vary by mode:

- The income and socio-economic characteristics of travellers might vary systematically by mode. Low-income users with low average VTTS might gravitate to mode A, while high-income users with high average VTTS might tend to choose mode B.

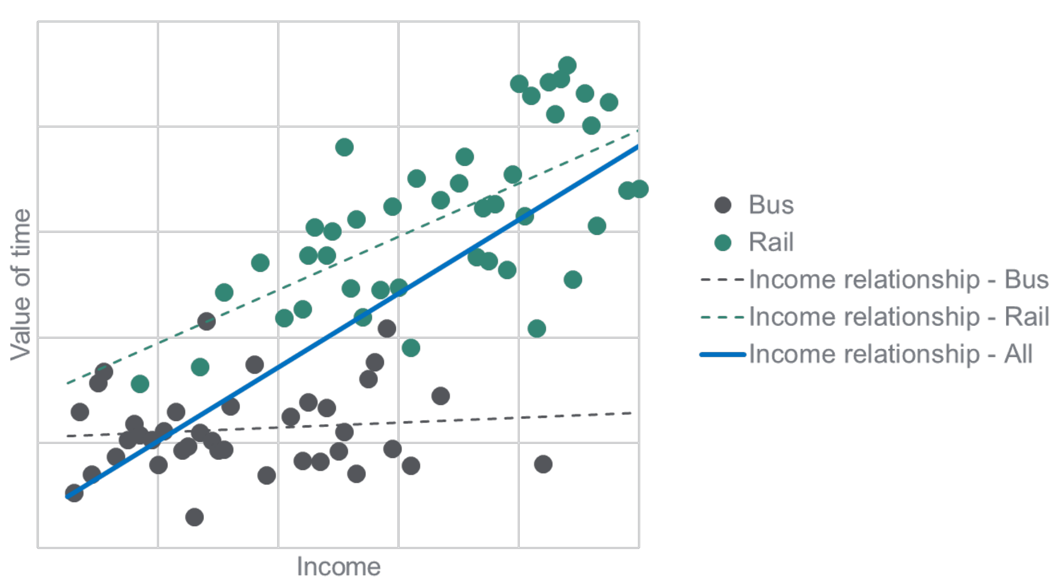
- The composition of trips and purposes might vary systematically by mode. Mode A might have a strong market share in short distance trips, while mode B might be stronger at longer distances.
- A cross section of people with given income and socio-economic characteristics making a trip will have a distribution of values of time (and individual values may vary according to the constraints faced). People with low VTTS for that trip will self-select into relatively low cost/high time modes and vice versa.
- For any individual, VTTS by mode may vary due to the different characteristics of the modes in terms of comfort, cleanliness, reliability, level of personal control and other quality attributes.

Mackie et al. (2003) argued that, the last point aside, individuals should theoretically have the same VTTS for a given trip regardless of the mode used. This favours an approach which takes into account the first three points through the income, socio-economic characteristics, and trip and purpose characteristics of the traffic modelled to the various sub-markets. Any remaining variation in VTTS should then reflect comfort effects.

The Department interpreted the modal ordering of values observed in the study as self-selectivity because it generally corresponded to the users' average incomes. This suggests that the analysis undertaken in the study might not have fully captured the role of income in variations in values between users of different modes. This is clearest in the absence of a relationship between income and the VTTS in the bus commuting model.

For non-work trips, the study attempted to control for income-based differences in values. It used the income elasticities from the behavioural model to calculate the appraisal values of travel time savings at a constant, average level of income. This did not undo the modal ordering observed above. The Department's view was that self-selectivity could have biased the income elasticities downwards, as those with a higher-than-average VTTS for their level of income are more likely to opt for a quicker, more expensive mode, whereas those with a lower-than-average VTTS for their income are more likely to do the opposite. As the income elasticities were estimated separately by mode and purpose in the behavioural model, it is possible that the true, stronger, "global" income effect was masked, as illustrated in Figure 5.

Figure 5. Income relationships estimated jointly and separately by mode



For work trips, on the other hand, distance variation was found to dominate modal variation in the appraisal values. Rail values are generally greater than car values, especially for longer trips, and the Department's view was that self-selectivity remained at play. Furthermore, the distance variation was considered to be a function of both the behavioural model parameters for time and cost sensitivity (which, given that time, cost and distance are highly correlated, capture the relationship between the VTTS and trip distance for a given individual, holding all other trip and traveller attributes constant) and the sample enumeration process (where the variation in VTTS by distance would largely be driven by the variation in typical trip and traveller attributes for journeys of different lengths as observed in NTS).

For appraisal purposes, the Department was content to recommend distance segmentation for business values, on the basis that these values offered a valid representation of the change in social welfare resulting from quicker business journeys (arising from the economic surplus earned by firms, combined with the individual welfare impacts perceived by their employees). Because it is not generally possible to identify the ultimate beneficiaries of this surplus (i.e. the owners of the factors of production) in a transport appraisal context, the Department treated this as a benefit to the overall economy without any distributional impacts. There are, however, practical difficulties of applying modally-segmented VTTS in a valid way using the rule-of-a-half, where the variation in values does not unambiguously relate to comfort or other quality attributes relating to the *use* (as opposed to the *current users*) of a particular mode (Mackie et al., 2003, section 8.3). Specifically, in such conditions, mode-switchers are treated anomalously in the appraisal. Little empirical work has been done to understand the practical implications of this.

Variations in values over time

New national VTTS studies are conducted infrequently, typically with significant time gaps between studies. In the case of the United Kingdom, 20 years separated the surveys underpinning the two most recent studies: the survey work for AHCG (1999) was conducted in 1994, whereas the survey work for Arup, ITS Leeds and Accent (2015a) was conducted in 2014. In the intervening period, the official VTTS is typically updated alongside GDP growth using a specified income elasticity. It is often believed that this income elasticity should be equal to one, but this convention has its origins in the CSA approach where the VTTS should increase at the same pace as the wage rate.

The means and conditions of travel change over time and user preferences change as a result. One can expect, then, that the income-adjusted growth in the VTTS does not capture changes in the VTTS. This concern is particularly relevant if one believes that the productivity of travel time (or more generally the disutility of travel time) is likely to change in response to improved connectivity and comfort. Against this background, DfT recently commissioned a scoping study from ITS Leeds and Arup (2018) to set out a framework for maintaining a robust VTTS over time.

The development of such a framework is ambitious and moves away from the default option in Western European countries, including the United Kingdom, to update using only the income elasticity. A simple extension of the default approach would be to combine uprated income data with new NTS data through the aforementioned implementation tool, such that the uprated VTTS values would also capture changes in travel patterns while assuming that the underlying behavioural framework remains fit-for-purpose. A question that remains is whether these two approaches can be combined without the risk of double counting (since part of the observed changes in travel behaviour could be a result of income growth).

More frequent data collection from smaller sample groups is, however, required to test the validity of the 2014-15 behavioural framework over time. This could be done in one of two ways. The first relies on incorporating emerging empirical evidence into the well-developed meta-analytical frameworks on the

VTTS in the United Kingdom and Europe (e.g. ITS Leeds, Arup and URS, 2013). The meta-analytical framework provides an independent source of information against which the outcomes of the default uprating procedure can be statistically verified. However, this option is only feasible when the meta-model(s) are regularly updated to continually provide sufficient new evidence. The second option allows for more direct empirical testing of the temporal stability of the assumed behavioural framework through the annual collection of new SP data using the same methodology as the original study. Since annual sample sizes of around 10-20% of the original data are perhaps practicable, it is recommended that the new data are jointly analysed with the original dataset while controlling for shifts in key VTTS parameters. A benefit of this approach is that narrower confidence intervals can be obtained, as long as the behavioural framework is judged appropriate (see also Wheat and Batley, 2015).

Frequently collecting new data within the United Kingdom, and possibly in other countries using a comparable framework, would help establish better inter-temporal and cross-country comparisons. This would facilitate empirical identification of changes in the VTTS, e.g. due to increased productivity of travel time. If and when such changes are identified, more detailed studies can be commissioned to seek understanding of what might be driving such changes.

Modelling, forecasting, appraisal and land use policy implications: DfT case studies

The updated WebTAG guidance released in July 2016 represented a step-change in appraisal for the Department. For the first time, employers' business values of travel time savings were directly grounded in WTP valuations, which the Department viewed as a major step forward in response to the ongoing debate around business values (and the influence of productive time use in particular). Implementing the new values in live appraisal work has had a material impact on the appraisal of many major investment projects in the Department’s portfolio.

Overall, given the journey purpose split of passenger travel and the reductions to business and other non-work VTTS, the updated guidance led to a moderate (around 10%) reduction in scheme benefits, but this masked significant variation on a scheme-by-scheme basis. Reductions in benefits were larger (sometimes up to 40%) where investments largely benefitted leisure or shorter-distance business travel. However, the new values also had a small to moderate positive impact on scheme benefits, where the investments predominantly benefitted commuters and longer-distance business trips.

There was also a pronounced modal pattern in the impacts, with larger reductions in benefits being more prevalent for road schemes compared to rail. The two major scheme case studies below illustrate some of these patterns. In addition, some results of simple Departmental portfolio testing are presented in Annex A – illustrating the overall distribution of impacts.

Case study 1: High-speed two

High-speed two (HS2) is a new high-speed rail network for the United Kingdom, connecting London with major cities in the Midlands and the north of England. It is a Y-shaped network that will be delivered in several stages. Trains will also run beyond the Y network to serve places such as Liverpool, Preston, Newcastle and Scotland. The impact of the new VTTS guidance (i.e. based on the Arup, ITS Leeds and Accent (2015a) study) on the economic appraisal of HS2 has been tested by applying the old VTTS guidance (i.e. based on the Mackie et al. (2003) study, but updated for income growth) to the latest modelling outputs. The impact of a revision of the wait time multiplier from 2.5 to 2.0 has been separated out from the impact of changes in the basic values of travel time saving so to isolate the impact of the new VTTS.

Table 6. HS2 appraisal impacts

Breakdown of impacts	Present value GBP billion (2015/16 price and discounting base year)			Overall % difference between new and old results
	Old VTTS, wait multiplier	New VTTS, old multiplier	New VTTS, new multiplier	
Transport user benefits (business)	56.6	63.5	61.2	8%
Transport user benefits (other)	20.0	18.3	17.1	-14%
Other quantifiable benefits (excluding carbon)	0.4	0.4	0.4	0%
Loss to government of indirect taxes	-4.1	-4.1	-4.1	0%
Net transport benefits (PVB)	**73.0**	**78.1**	**74.6**	**2%**
Wider Economic Impacts	16.3	18.3	17.6	8%
Net benefits including WEIs	**78.6**	**84.4**	**80.7**	**3%**
Revenues	43.6	43.6	43.6	0%
Capital costs	55.8	55.8	55.8	0%
Operating costs	27.6	27.6	27.6	0%
Cost to the broad transport budget	**39.8**	**39.8**	**39.8**	**0%**
Benefit-cost ratio	1.8	2.0	1.9	2%
Benefit to cost ratio (with wider economic impacts)	**2.2**	**2.4**	**2.3**	**3%**

The journey purpose split of the market expected to be served by HS2 is quite atypical of passenger travel in the United Kingdom generally (across all modes as well as rail specifically), with approximately 45% business travel, 45% other non-work and the remainder commuting. Given this fact, the fall in VTTS for other non-work travel, and the marked rise for long-distance rail travel, engender two strong opposing influences on the benefit to cost ratio (BCR) (Table 6). However, as the Department's guidance for estimating wider economic impacts (WEIs) partially pivots off the value of business user benefits (which is primarily composed of travel savings), the boost to business benefits induces a comparable percentage increase in WEIs, lifting the overall BCR. The reduction of the wait time multiplier partially offsets this, as HS2 is forecast to cut waiting times, which are valued relatively less under the new guidance.

Case study 2: Roads Investment Strategy 1

The first roads investment strategy (RIS1) outlines the Department's long-term programme for motorways and major roads and is intended to put in place the stable funding needed to plan ahead. A cornerstone of RIS1 is a multi-year investment plan to improve the strategic road network (SRN). Covering the period 2015-20, this comprises a GBP 15 billion programme of over 100 major schemes. For appraisal purposes, modelling was carried out by the Department in 2014 to support the case for investment. The impact of the new VTTS guidance on these results has been tested by applying the new VTTS to the original modelling results (Table 7).

Table 7. RIS1 appraisal impacts

Breakdown of impacts	Present value GBP million (2010 price and discounting base year)		% difference
	Old VTTS	New VTTS	
Time savings: commuters	4 769	6 916	45%
Time savings: other non-work	12 830	9 568	-25%
Time savings: business	12 120	8 175	-33%
Time savings: freight	9 699	9 699	0%
Vehicle operating costs	1 220	1 220	0%
Greenhouse gases (CO2)	-758	-758	0%
Local air quality (nitrogen oxides and particulate matter PM10)	-23	-23	0%
Accidents	-386	-386	0%
Noise	-31	-31	0%
Wider public finances (indirect taxation revenues)	902	902	0%
Present value of benefits (PVB)	**40 342**	**35 282**	**-13%**
Present value of costs (PVC)	**8 757**	**8 757**	**0%**
Initial BCR	**4.6**	**4.0**	**-13%**
Reliability: commuters	1 845	1 338	-27%
Reliability: other non-work	4 976	1 855	-63%
Reliability: business	5 070	1 710	-66%
Reliability: freight	3 749	1 875	-50%
Total reliability	**15 640**	**6 778**	**-57%**
Wider economic impacts	5 655	6 007	6%
Landscape	-339	-339	0%
Adjusted PVB	**61 298**	**47 729**	**-22%**
Adjusted BCR	**7.0**	**5.5**	**-22%**

As with the HS2 case, the revision to other non-work VTTS places downwards pressure on the BCR, with some off-setting increases to commuting benefits. However, the comparative lack of long-distance business travel results in a substantial fall in business user benefits which, coupled with the halving of the reliability ratio, causes a large fall in the adjusted BCR (the initial BCR, under UK guidance, omits reliability, landscape and WEIs). As the economic case for RIS1 was originally very strong, however, the case for investment was deemed by the Department to remain robust and the overall value for money rating of the package remains "very high". Under DfT guidance (DfT, 2017b), this is the ranking reserved for schemes with BCRs in excess of 4 (including consideration of non-monetised impacts, risk and uncertainty).

Summary and synthesis

In 2014-15, Arup, ITS Leeds and Accent conducted the first substantive national study of VTTS in some 20 years. In the period 2015-17, the UK Department for Transport assimilated the findings of the study, consulted stakeholders on proposed changes to appraisal guidance and, following some refinements (especially in terms of distance-varying values), published updated guidance.

In accordance with direction imposed by ITF, this paper has covered insights and conclusions from the UK experience, including the following:

- the rationale for the investigation particularly around productive time use and the relationship with VTTS
- the approaches investigated and the reasons for the selected willingness-to-pay (WTP) approach
- the key findings from the 2014-15 study
- the approach to implementation and lessons for other countries
- modelling, forecasting, appraisal and land use policy implications due to distance-based VTTS and potentially time-varying VTTS if the level of time use increases with technologies over time.

Overall, considering the case studies and wider portfolio testing, it is apparent that introducing distance-varying business VTTS has strengthened the case for investment in long-distance, inter-urban travel where business and commuting are the dominant trip purposes. There are, however, grounds for challenging the Department's decision to use distance variation in practical appraisal guidance in the absence of detailed testing of alternative dimension of variation, such as journey time and cost. Given the strength of these other variables in the behavioural modelling, where distance itself was usually not significant, they may present a more plausible basis for application in appraisal. All other things being equal, segmenting by journey time would be expected to worsen the case for investing in travel time savings on already fast routes, as they would have shorter travel times for a given trip distance than slower routes. A corresponding argument could be made for segmenting by journey cost.

In terms of the debate around productive or worthwhile time use, the updated guidance has perhaps not had the effect that one might have expected. Valuations for long-distance rail travel have actually increased, whereas sceptics might have expected the new valuations to be lower because of controlling for time use. There are a number of intuitive reasons why time savings might be worth more on longer trips, as outlined in the Department's October 2015 consultation document. However, this finding does necessarily dismiss the underlying view that productive or worthwhile time use should reduce unit valuations of VTTS.

There are a number of possible reasons why the 2014-15 study did not detect statistically significant effects of time use. For example, there is a self-selectivity argument that those who get bored easily or who have the greatest working time constraints, and therefore a higher prior VTTS, may be more inclined to undertake leisure or work while travelling. This could induce downwards bias on the time use coefficients in the modelling, making it more difficult to estimate significant parameters. Another possibility is that respondents, when intercepted for the survey, were not always fully cognisant of the activities they are able to undertake during travel. Time use was not included directly as a choice attribute, but indirectly as a reference trip attribute. It is possible that an alternative valuation approach could yield different results.

Despite these concerns, the Department is confident that the updated VTTS within WebTAG provides a defensible basis for the appraisal of business travel time savings. They robustly represent the average WTP for time savings, given current market conditions and the state of technology. In any case, there would be significant practical implementation challenges associated with any move to business VTTS explicitly segmented by time use. Firstly, there is no obvious source of data currently available to provide robust assumptions on how travel time is used at present, let alone a method for forecasting this into the future. Secondly, travel time use itself is not in the domain of policy interventions. Rather, it is the opportunity to use travel time more advantageously that investment can confer.

Moving forwards, with the dawn of autonomous vehicles (AVs) there is likely to be an increasing need to expand the evidence base around the impact of travel time use on VTTS. The Department has tentatively taken early studies by Wadud, MacKenzie and Leiby (2016) and Kolarova et al. (2017) to indicate an approximately 25% reduction in the VTTS with AVs compared to conventional cars. The evidence to date is thin, however, and there is no authoritative figure to use in policy appraisal. Given the extremely low penetration of the technology, this issue is presently expected to remain on the research frontier. However, the Department is of the view that concerted effort will be needed in the medium term to develop defensible VTTS estimates for policy appraisal involving AVs.

Notes

1 This paper uses the terms "DfT" and "the Department" interchangeably.

2 As noted by Batley et al. (2017), the VTT calculations were dependent upon the size of the time change from the reference (denoted Δt). Therefore, in translating these behavioural values to appraisal values, it was necessary to make a definitive assumption concerning Δt. In correspondence with recent assumptions applied in Denmark and Sweden and after conducting several sensitivity tests, the authors of this paper eventually settled upon a Δt of ten minutes.

References

AHCG (1999), "The value of travel time on UK roads", Report to Department for Transport, Accent and Hague Consulting Group.

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

Arup, ITS Leeds and Accent (2015b), "Provision of market research for value of travel time savings and reliability", Walk and Cycle report for the Department for Transport, London, https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/470237/vtts-walk-and-cycle-report-issue-14-aug-2015.pdf.

Black, I. and J. Towriss (1993), "Demand effects of travel time reliability", Centre for Logistics and Transportation, Cranfield Institute of Technology, UK.

DfT (2013), "Understanding and valuing the impacts of transport investment: Latest DfT technical research and next steps in transport appraisal", Department for Transport, London, https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/253485/technical-research-next-steps-appraisal.pdf.

DfT (2014), "TAG unit A1.3: User and provider impacts", Department for Transport, London, https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/539338/webtag-tag-unit-a1-3-user-and-provider-impacts-november-2014.pdf.

DfT (2015), "Understanding and valuing impacts of transport investment: Values of travel time savings", *Moving Britain Ahead*, Department for Transport, London, https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/470998/Understanding_and_Valuing_Impacts_of_Transport_Investment.pdf.

DfT (2016a), "Understanding and valuing impacts of transport investment: Value of travel time saving consultation response", *Moving Britain Ahead*, Department for Transport, London https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/544165/understanding-and-valuing-the-impacts-of-transport-investment-values-of-travel-time-savings-consultation-response.pdf.

DfT (2016b), "TAG unit A1.3: User and provider impacts, forthcoming change, November 2016", Department for Transport, London, https://www.gov.uk/government/publications/webtag-tag-unit-a1-3-user-and-provider-impacts-november-2014.

DfT (2017a), "TAG unit A1.3: User and provider impacts", Department for Transport, London, www.gov.uk/government/publications/webtag-tag-unit-a1-3-user-and-provider-impacts-march-2017.

DfT (2017b), "DfT value for money framework", Department for Transport, London, www.gov.uk/government/publications/dft-value-for-money-framework.

Fickling, R. et al. (2009), "Productive use of rail travel time and the valuation of travel time savings for rail business travellers", Final report to the Department for Transport, https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/4003/productive-use-of-travel-time.pdf.

Fowkes, A., P. Marks and C. Nash (1986), "The value of business travel time savings", Working Paper 214, Institute for Transport Studies, University of Leeds, https://core.ac.uk/download/pdf/53694.pdf.

Fowkes, A. (2001), "Principles of valuing business travel time savings", Working Paper 562, Institute of Transport Studies, University of Leeds, http://eprints.whiterose.ac.uk/2064/1/ITS39_WP562_uploadable.pdf.

Harrison, A. (1974), *The Economics of Transport Appraisal*, Croom Helm, London.

Hensher, D.A. (1977), *Value of Business Travel Time*, Pergamon Press, Oxford.

ITS Leeds, John Bates and DTU (2010), "Updating appraisal values for travel time savings Phase 1 study", Report to the Department for Transport, https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/251995/updating-vtts-phase-1-dft-006.pdf.

ITS Leeds, John Bates and KTH (2013), "Valuation of travel time savings for business travellers", Main report, prepared for the Department for Transport, London, https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/251997/vtts_for_business_main_report-dft-005.pdf

ITS Leeds, Arup and URS (2013), "Meta-analysis of post-1994 values of non-work travel time savings", Prepared for the Department for Transport, https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/252088/meta-analysis-vtts-dft-011.pdf.

ITS Leeds and John Bates (2013), "Values of travel time savings: Understanding the uncertainty around the non-work values", Final report, prepared for Department for Transport, https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/252009/statistical-confidence-vtts-dft-010.pdf.

ITS Leeds and Arup (2018), "Programme for maintaining a robust valuation of travel time savings: Feasibility study", Final Phase 2 Report, prepared for the Department for Transport, https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/716493/scoping-study-on-updating-values-of-travel-time-savings-phase-2.pdf.

Kolarova, V. et al. (2017), "Estimation of value of time for autonomous driving using revealed and stated preference methods", Paper presented at European Transport Conference 2017, https://aetransport.org/en-gb/past-etc-papers/conference-papers-2017?abstractId=5736&state=b.

MVA, ITS Leeds and TSU Oxford (1987), "The Value of Travel Time Savings", Policy Journals, 1987.

Mackie, P. et al. (2003), "Value of travel time savings in the UK", Working Paper no.567, Institute of Transport Studies, University of Leeds, Report to Department for Transport, http://eprints.whiterose.ac.uk/2079/2/Value_of_travel_time_savings_in_the_UK_protected.pdf.

Robles Alejo, E. (2017), "Understanding passengers effective use of travel time", ITS MSc Dissertation, Institute for Transport Studies, University of Leeds.

Wadud, Z., D. MacKenzie and P. Leiby (2016), "Help or hindrance? The travel, energy and carbon impacts of highly autonomous vehicles", *Transportation Research Part A: Policy and Practice*, Vol. 86, pp. 1-18, https://doi.org/10.1016/j.tra.2015.12.001.

Wardman, M, et al. (2015), "How should business travel time savings be valued?", *Economics of Transportation*, Vol. 4/4, pp. 200-214, https://doi.org/10.1016/j.ecotra.2015.08.003.

Wheat, P. and Batley, R. (2015) "Quantifying and decomposing the uncertainty in appraisal values of travel time savings", *Transport Policy*, Vol. 44, pp. 134-142, https://doi.org/10.1016/j.tranpol.2015.06.010.

Annex A. DfT portfolio testing

Figure A.1. Adjusted benefit to cost ratios for a range of strategic road network schemes
(error bars indicate low/high range)

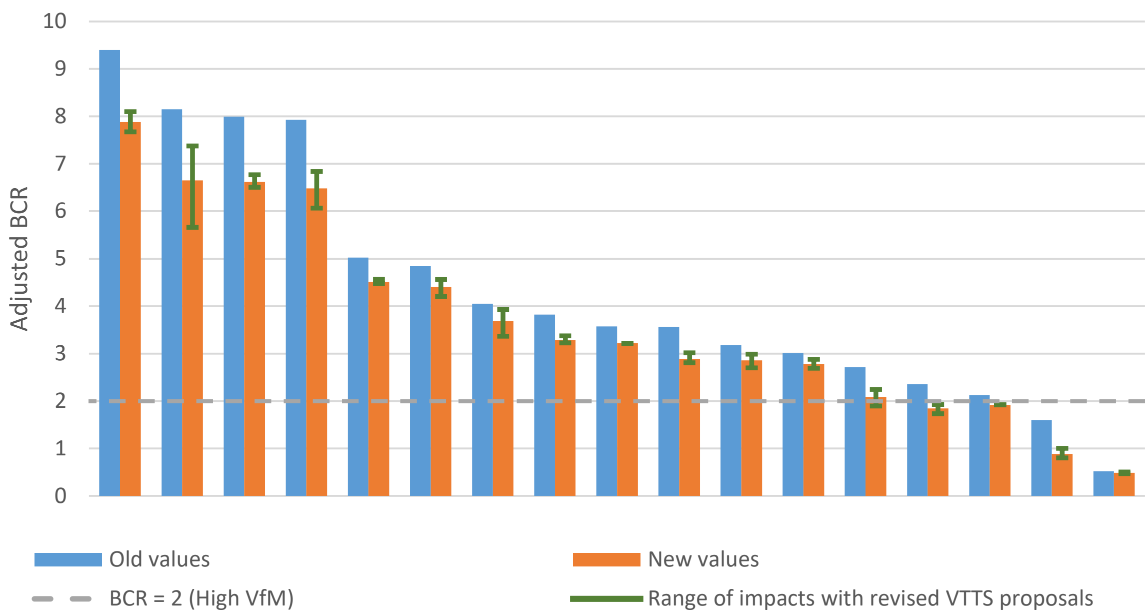


Figure A.2. Adjusted benefit to cost ratios for a range of rail schemes
(error bars indicate low/high range)

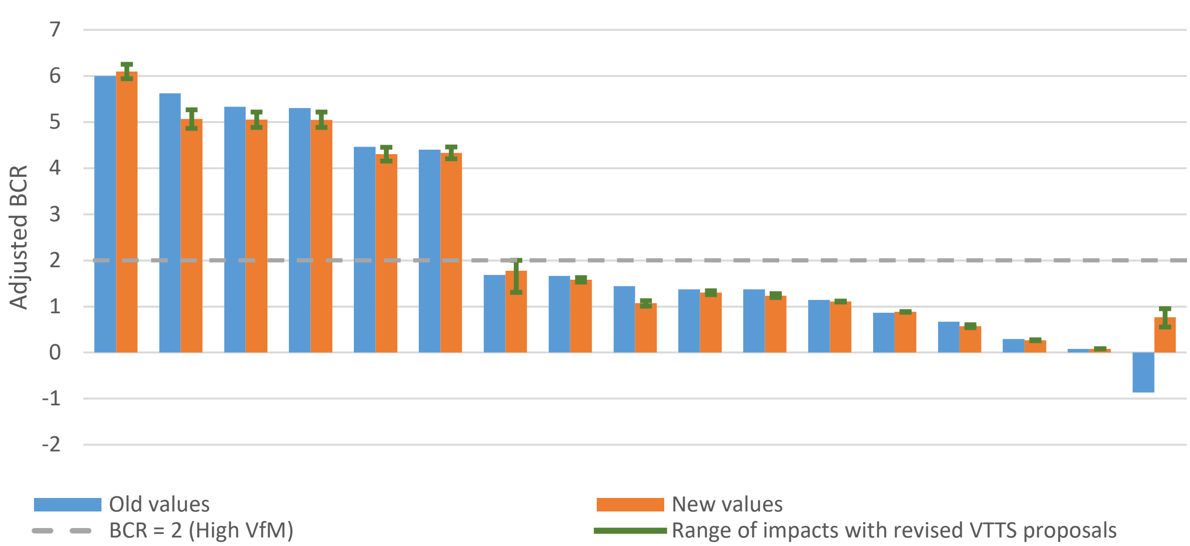
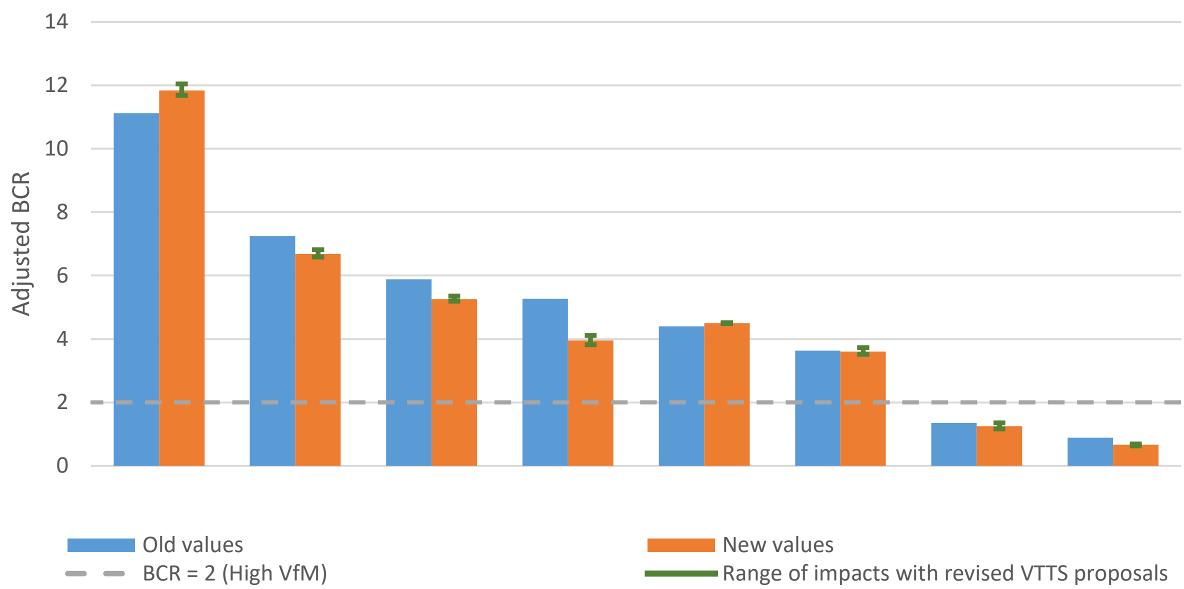


Figure A.3. Adjusted benefit to cost ratios for a range of local road schemes
(error bars indicate low/high range)



International Transport Forum

Worthwhile Use of Travel Time and Applications in the United Kingdom

This paper outlines the rationale, methodologies, key findings and policy implications of the national Value of Travel Time Savings (VTTS) study conducted in Britain during 2014-15. The study found VTTS varied with distance, trip purpose and mode of travel but not with worthwhile use of travel time. Using two case studies, the paper discusses the approach to implementation of the new VTTS estimates and lessons for other countries.

All resources from the Roundtable on Zero Value of Time are available at: www.itf-oecd.org/zero-value-time-roundtable.

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