National Highways

Freight value of time and value of reliability

Final report

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1. Executive summary

The Arup AECOM Consortium (Arup, Aecom, the University of Leeds and Significance) was recruited under the Specialist Professional and Technical Services 2 (SPaTS2) Framework, Work Order T0825, to determine updated Freight Values of Time (VTT) and Values of Travel Time Reliability (VTTR) for National Highways (NH) and the Department for Transport (DfT).

Prior to this study, freight value of time savings in DfT Transport Analysis Guidance (TAG) accounted solely for the driver costs. This study set out to advance the road freight value of time metrics used for appraisal by providing a more sophisticated analysis based on the additional factors of reliability, vehicle costs, and cargo costs. This final report covers the results of the stated preference survey, and metrics for updated freight VTT and VTTR for potential incorporation into TAG.

The results draw on a sample of 472 freight industry respondents (from a total sample of 602). Rejections were based on responses that would imply travel higher than the speed limit, duplicate responses, irrational responses, and those with an unusually high value of time.

A sample of OGV1 (rigid vehicles over 3.5 tonnes with two or three axles), OGV2 (rigid and articulated vehicles over 3.5 tonnes with four or more axles) and LGVs (rigid light goods vehicles up to 3.5 tonnes), across shippers (cargo traders), carriers (transportation providers), and those headed to ports, and not to ports was used, as set out in Table 1, and was expanded with data from the Continuing Survey of Road Goods Transport (CSRGT) to provide a representative output. Note that 'to port' does not include journeys *from* a port.

Table 1: Sample sizes used for analysis

		OGV1	OGV2	LGV	All
Shipper	Not to port	55	18	18	91
	To port	26	31	22	79
Carrier	Not to port	122	39	26	187
	To port	49	47	19	115
Total		**252**	**135**	**85**	**472**

The updated freight Values of Travel Time (VTT) and Travel Time Reliability (VTTR) are presented in Table 2. OGV 1 and OGV2 were combined to a single OGV value to improve the robustness of the output, The same values are presented for OGVs and LGVs across the shipper segmentation, and the same values are presented to port and not to port journeys across the carrier segmentation[1].

Table 2: Summary of recommended VTT and VTTR values per hour

<table>
<tr><th rowspan="2"></th><th rowspan="2"></th><th colspan="2">VTT (£2022 prices)</th><th colspan="2">VTTR (£2022 prices)</th></tr>
<tr><th>OGV</th><th>LGV</th><th>OGV</th><th>LGV</th></tr>
<tr><td>Shipper</td><td>Not to port</td><td colspan="2">£72.21</td><td colspan="2">£ 12.96</td></tr>
<tr><td></td><td>To port</td><td colspan="2">£ 94.87</td><td colspan="2">£ 17.02</td></tr>
<tr><td>Carrier</td><td>Not to port</td><td rowspan="2">£ 81.24</td><td rowspan="2">£ 63.83</td><td rowspan="2">£ 46.77</td><td rowspan="2">£ 44.75</td></tr>
<tr><td></td><td>To port</td></tr>
</table>

The derived VTT values are between 3.5 and 4.1 times higher than those in the current TAG, once price base and GDP are corrected for. For carriers (time-dependent transport cost component), rather similar VTTs

[1] See Section 5: OGV1 and OGV2 were combined because in initial analysis, OGV1 produced higher VTTs than OGV2, which did not reflect our belief that OGV2 would have higher vehicle and staffing costs. The same values are presented for OGVs and LGVs across the shipper segmentation because the sample size for LGVs inhibited robust modelling. The same values are presented to port and not to port journeys across the carrier segmentation because transport costs per km were expected to be similar regardless of the origin-destination.

were obtained as in the Netherlands, but for shippers the UK values were substantially higher than both the Netherlands and the weighted average in Norway (though the Norwegian study also found commodities with high VTT for shippers). These high VTTs for shippers may be related to: capital invested in the goods, deterioration of the goods during transport, loss of shelf life for goods arriving late, disruption of production process for goods arriving late and suboptimal logistics (bigger inventories, number and location of depots) due to longer travel times.

The VTT and VTTR values were adapted to fit the segmentation in TAG[2] by combining cargo costs (captured by shippers and not currently captured in TAG), and transport costs (captured by carriers). The proposed values are shown in Table 3.

When used in appraisal, to avoid double-counting, these values should be recognised as including non-fuel time-dependent transport costs. The table below thus would replace Table A1.3.1 driver-related time values, and the time-related part of Table A1.3.14 (the non-fuel vehicle operating costs).

Table 3: Representative VTT and VTTR per hour using hypothetical weighted averages

	VTT (£2022 prices)	VTTR (£2022 prices)	Reliability ratio (at average)
Average	£ 132.19	£ 56.21	0.43
Average LGV	£ 133.10	£ 57.18	0.43
Average OGV	£ 131.86	£ 55.85	0.42

[2] To arrive at these nationally representative averages for the measures of interest applicable in appraisal practices, data from the CSRGT survey (for OGV) was combined with available statistics for LGV vehicles to arrive at the relevant weights used for averaging.

2. Introduction

2.1 Objectives

The Arup AECOM Consortium (Arup, Aecom, University of Leeds and Significance) was recruited under the Specialist Professional and Technical Services 2 (SPaTS2) Framework, Work Order T0825, to determine updated Freight Values of Time (VTT) and Values of Travel Time Reliability (VTTR) for National Highways (NH) and the Department for Transport (DfT).

As described in the scope template, “the objective of this research is to produce robust, credible and nationally (England[3]) representative valuations of freight time and freight reliability that could be included within DfT’s TAG guidance and used in the appraisal of road transport investments”.

This follows the DfT Appraisal and Modelling Strategy (DfT, 2019) which identified a need for up-to-date values of freight time and a method that advances the current approach of using the cost of employment of the driver. International practices were found to be more complete, through their capture of reliability, vehicle costs, and the costs of goods in transit. Further, they provided more detailed segmentation by industry, location, and journey type. The methods used to inform this approach presents models to replicate for the UK context.

The scope requirement presents Table 4 as a minimum segmentation to be achieved for value of time and value of reliability. The entry cells in the table are intentionally left blank.

Table 4: Minimum segmentation of freight values of time and reliability sought in UK study

	LGV	OGV1	OGV2
Trips to ports			
Carrier (VTT related to vehicles and staff)			
Shipper (VTT related to cargo)			
Total (sum of above)			
Other trips			
Carrier (VTT related to vehicles and staff)			
Shipper (VTT related to cargo)			
Total (sum of above)			

The scope included use of stated preference techniques and achievement of a representative sample, demonstrating engagement with carriers, own account shippers, and shippers that contract out.

Four work packages were defined, with the following deliverables:

- Work Package 1:
    - Desk-based international review of how other countries have valued freight time and reliability, with a particular focus on the methodologies employed.
    - Identification of key lessons from previous studies and describe implications for the design of the UK study.

[3] Note that this study was later refined to include journeys that begin or end in England, Scotland or Wales, and for brevity is referred to as the UK study throughout.

    - Provision of evidence on the range of contractual arrangements within the freight sector such that the survey can be designed to reduce the chances that responses are anchored on each respondent's current contracts.
- Work Package 2:
    - Design of research methodology and questionnaire for a new UK stated preference study into the value of time and reliability which will deliver the outputs listed in the 'Objectives' section above.
    - Identification of the survey population, proposed approach to segmentation and sampling method.
- Work Package 3:
    - Pilot survey.
    - Identification of lessons from pilot.
    - Amend questionnaire / stated preference design as appropriate.
- Work Package 4:
    - Full survey.
    - Data analysis.
    - Identification of new values of time for use in appraisal.

2.2 Work Package 4

The findings from deliverables for work packages 1 to 3 are summarised in Section 3 below. Work package 4 builds on the previous work packages to provide a full stated preference survey and value of travel time (VTT) and travel time reliability (VTTR) figures. VTTs and VTTRs are then converted to fit UK and TAG appraisal practices.

The survey approach and outputs are set out in Section 4. Analysis based on the survey outputs and conversion for TAG appraisal application is set out in Section 5. Assurance undertaken for the survey and the analysis are presented in Section 6.

3. Work Package summaries

This section provides summaries of the previous work packages which build up to inform the output of this Work Package 4 report. The outputs for the work packages were technical notes which were split out based on the topics. A summary of the work packages and then the output technical notes is provided below.

3.1 Work Package 1

Work package 1 set out to provide a review of freight value of time and reliability assessment practices, drawing on international literature, and a review of working arrangements in the UK to understand how advanced approaches could be applied in the UK context. Technical note 1.1 provided an international review and technical note 1.2 provided the review of UK work arrangements.

3.1.1 Technical Note 1.1

Technical Note 1.1 (TN 1.1) presented an international review of approaches to deriving values of transport time (VTT) and values of transport time reliability or variability (VTTR) in freight transport. The definition of the freight VTT and its components were discussed alongside the valuation methodologies used for comparison with the UK TAG approach. Research conducted in Australia, Belgium, Denmark, Finland, France, Germany, Italy, Netherlands, Norway, Sweden, Switzerland, UK, USA, and other studies were referenced. This body of research informed the methodology used for the study of road freight VTT and VTTR in the UK later in work packages 3 and 4.

The note contained a series of recommendations across components to capture in VTT and VTTR, data collection and segmentation, and the modelling approach. These included:

- Distinguishing between the transport cost component and the cargo cost component of freight VTT. The transport cost component is the cost to transportation providers, otherwise referred to as carriers, and the cargo cost component is the cost of the goods in transit, incurred by shippers. These can be derived from stated preference (SP) surveys and combined for an overall VTT.
- The same SP surveys can be used to query reliability.
- Incorporating all time-related components (wages, time-dependent vehicle costs, cargo component) into the VTT where currently driver wages are used for the VTT and vehicle operating costs are treated separately. This better aligns metrics to the journey time saving outcomes that transport interventions are typically attempting to achieve.
- Using the standard deviation approach for VTTR, which aligns with the non-freight approach in the UK and accommodates forecasting changes in reliability where other methods are restrictive. Present reliability in the SP survey as a time choice rather than in standard deviations.
- Recruiting firms for SP surveys by phone rather than visiting firms, where the Norwegian experience demonstrates that this is cheaper and still effective.
- As is typical in other studies, using binary SP choices with a limited number of attributes that pivot around a reference shipment.
- Identifying a sampling approach which segments based on specific attributes, in reference to the quadrant approach used in Halse et al. (2019), which enables the estimation of coefficients of the discrete choice models with the smallest sample size required. This recognises the challenge to recruit respondents and informs the target sample of 600 used for work package 4.
- Discrete choice models can be estimated consistently with a non-presentative sample, with a minimum of 50 SP interviews required for each market segment that is distinguished in the model. The estimated models must then be expanded/corrected to become representative of the population studied. This informs the use of the Continuing Survey of Road Goods Transport (CSRGT) to expand the study.

- Segmenting by vehicle type (LGV, OGV1, and OGV2) and trips to seaports or other transhipment locations as these are likely to have different costs and cargo mixes.
- Testing dependence of the VTT and VTTR on commodity type, noting wages and vehicle cost components are unlikely to vary but cargo and reliability components might.
- Testing an MNL model approach and a mixed logit model approach to identify which provides the best log-likelihood value and stability. A log-willingness-to-pay-space model is also proposed to be tested. Both additive and multiplicative forms will be tested e.g. to account for distance effects (time and cost damping).

3.1.2 Technical Note 1.2

Technical Note 1.2 (TN 1.2) provided a review of contractual arrangements used in the road and freight transport sector in the UK and discussed the implications of heterogeneity of the goods, treatment of confidential information, nonlinearity, and wider supply chain effects. The note provided a series of recommendations that sit alongside those in technical note 1.1 to inform the study design. These included:

- Distinguishing between own account shippers and carriers/hauliers and shippers that contract transport to other firms. Own account shippers incur transport and goods component costs.
- An observation that contracts vary, and over half of freight transport is carried out without a contract which can result in varied prices. Firms should consider typical costs rather than look to specific instances.
- Further observations that freight transport is heterogeneous and can differ by value density, perishability of goods, shipment size, trip distance and time, and the impact of delay. Segmentation proposed in TN 1.1 and testing dependence on commodity type responds to heterogeneity. The study should also aim for a mix is responses from firms of different sizes.
- Notes that the study must align with GDPR principles and data aggregated. Where firms are reluctant to share costs and prices, estimates can be proposed, and firms confirm whether these estimates are reasonable.
- Notes that non-linear effects of costs, reliability, and error terms are possible and non-linear specifications should be tested.
- Notes that shippers may not immediately consider costs and reliability effects on their supply chain and should be encouraged to do so.

3.2 Work Package 2

Work Package 2 set out to define the methodology for the stated preference survey, including the questionnaire and sampling approach. Technical Note 2.1a (TN 2.1a) presented the overarching framework, technical note 2.1b (TN 2.1b) details the stated preference experiment approach which is attached in Appendix A.1, and technical note 2.2 (TN 2.2) explains the sampling approach. Technical Note 2.3 (TN 2.3) describes how the study was paused in response to Covid-19.

3.2.1 Technical Note 2.1a

Technical Note 2.1a set out the overarching framework for the study design. VTT and VTTR were defined and the option to incorporate staff and vehicle time costs, which were previously treated as transport costs, into VTT is presented. Technical Note 1.1 recommended that these are incorporated in VTT.

The scope of the study was defined, which included solely considering road freight and focusing on journeys made on the Strategic Road Network (SRN) that begin and end in England, Scotland, or Wales. Journey components were to be identified, such as origin and destination, loading and unloading locations of the transport leg, vehicle type (LGV, OGV1, OGV2), and interaction with other modes. The study would also quantify the cargo and transport costs component of VTT and VTTR, with interviews targeted at shippers and carriers/hauliers in accordance with Technical Note 1.1.

The survey would use a stated preference approach and will be expanded using the Continuing Survey of Road Goods Transport (CSRGT) to achieve a representative output. The sample would be segmented by vehicle type, trips to/from ports and other trips, and by carriers and shippers. 50 SP interviews were required to successfully estimate a logit model and, based on the segmentation, the sampling requirement was proposed in Table 5. A sum 600 SP interviews were deemed necessary which would be recruited using telephone interviews. Note that 'to port' does not include journeys *from* a port.

Table 5: Proposed sampling segmentation from Work Package 2

	LGV	OGV1	OGV2
Trips to Ports			
Carrier (VTT related to vehicles and staff)	50	50	50
Shipper (VTT related to cargo)	50	50	50
Total (sum of above)	**100**	**100**	**100**
Other trips			
Carrier (VTT related to vehicles and staff)	50	50	50
Shipper (VTT related to cargo)	50	50	50
Total (sum of above)	**100**	**100**	**100**

A pilot study was planned, which comprised Work Package 3, to test the survey design and response rates. The pilot aimed for 60 responses, 10% of the amount required in the final survey for Work Package 4, and included questions on firm typology, the stated preference experiences, and feedback questions seeking evaluation of the survey by respondents.

The SP exercises were proposed to be split in two, the first focusing on VTT and the second on VTTR. The exercises provided a choice between speed and cost scenarios. To test reliability, standard deviation was used to produce varying arrival times. An example is presented in Figure 1.

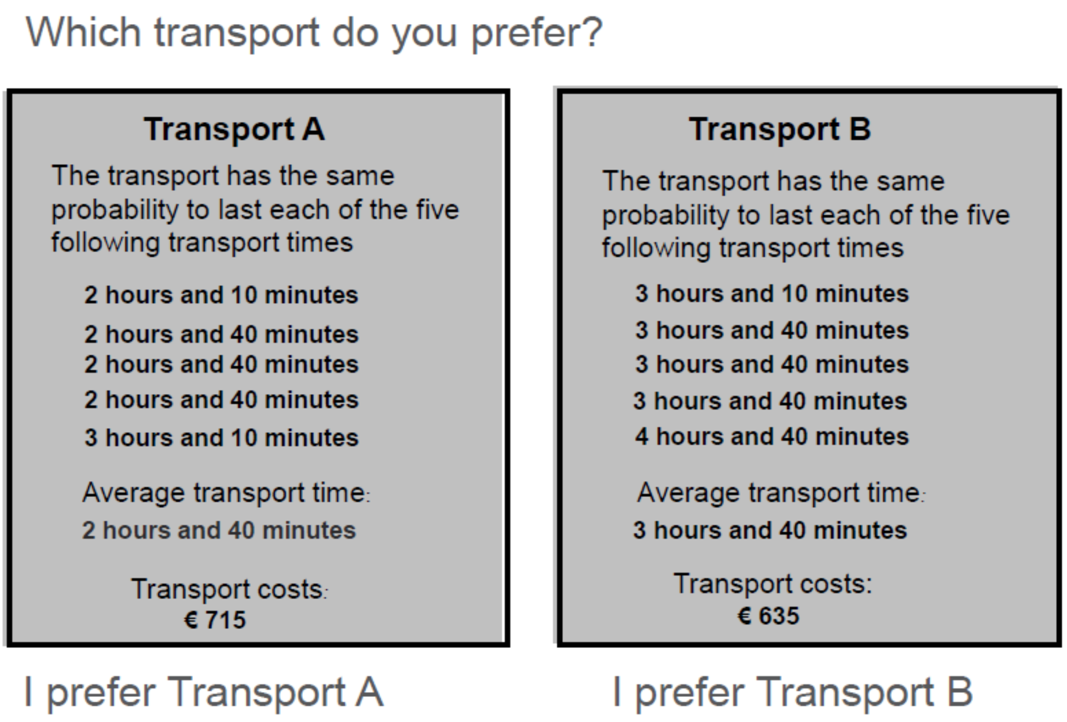


Figure 1: Example VTTR choice to present to respondents

When analysing responses, these were proposed to first be screened and checked. As proposed in technical note 1.1, various specifications were proposed to be tested to arrive at the specification that best described the data. Alternative specifications could also be tested, which may identify additional explanatory variables, unobserved heterogeneity, and non-linearity.

The note also set out the need to convert the outputs of the survey analysis for use in appraisal. This is confirmed later in this Work Package 4 report, following discussion on functional form with National Highways and the Department for Transport.

3.2.2 Technical Note 2.1b

Technical Note 2.1b reported the chosen methodology for the stated preference survey designs. As the calculations in the note cannot be readily summarised, the note is attached in Appendix A.1.

The note set out that each respondent will participate in two choice experiments:

- SP1: a two-attribute experiment with time and cost.
- SP2: a three-attribute experiment with time, cost and reliability.

On SP1, the note defined the boundary value of time (BVTT), the reference-based approach used for the choices presented to respondents, segmentation used, the BVTT ranges and the time and cost ranges that inform this, and the approach to presenting choices to respondents.

On SP2, the note defined the reliability ratio (RR) used to express value-of-time reliability, the boundary reliability ratio (BRR), the BRR ranges and the time ranges that inform this, the use of standard deviation and presentation as travel time options, and the approach to presenting choices to respondents.

3.2.3 Technical Note 2.2

Technical Note 2.2 set out the sampling and recruitment strategy for the pilot SP survey. Following technical note 2.1a, obtaining 60 completed interviews was proposed for the pilot study, with 30 shippers and 30 carriers. The survey aimed for representation across company types, value of goods, freight vehicle type, and journey origin/destination.

A mixture of telephone and online interviews were proposed, in accordance with technical note 1.1, to achieve reasonable response rates and cost. The recruitment methodology was as follows:

- Interviewer to introduce the survey, build rapport and gain willingness to participate with the appropriate person from the organisation.
- Confirm eligibility of the business within agreed quotas.
- Search for the correct person in the business with an appropriate level of seniority to complete the survey, i.e. a transport or supply chain manager, and establish that they are engaged with the survey subject.
- Agree participation and confirm contact details of the preferred respondent.

Following this process an email with introductory text and a link to the survey platform (SNAP, the survey software) would be shared.

All data collection would be carried out in accordance with the Code of Conduct of the Market Research Society, respecting requirements for confidentiality.

3.2.4 Technical Note 2.3

Technical Note 2.3 summarised the project pause response to Covid-19. The note summarised the work done to date and the proposal to engage business for the work package 3 pilot study once the freight industry normalises. The decision was made to pause the study because engagement with the freight industry was expected to become challenging and disruption to freight operation was expected to produce responses that may not have reflected normal operation pre and post Covid-19.

3.3 Work Package 3

Work Package 3 included undertaking a pilot survey and analysis of the responses to test sampling and the methodology. Technical Note 3.1 set out the sampling response and technical note 3.2 presented analysis on responses to the questionnaire.

3.3.1 Technical Note 3.1

Technical Note 3.1 reported on the pilot study sampling, respondent profile, and recommendations for the work package 4 main study. Sampling ran between 20th July 2021 and 3rd September 2021, extending beyond the 4 weeks proposed to accommodate the summer holiday period. Businesses noted that the holiday period, Brexit arrangements, and the on-going impact of Covid-19 restricted their capacity to respond to the survey. From 400 businesses contacted, 30 responded, which amounted to 50% of the 60 originally intended.

Of the 30 responses, 16 were hauliers and 14 were shippers, presenting a near even split as intended. Businesses of varying size, region, product, and sector were also represented. The technical note made a series of recommendations recognising the challenge to recruit 60 respondents as intended:

- Extended the fieldwork timescales, team, target number of businesses to contact, and account for the cost to do this.
- Recognised the possibly of a Covid-19 resurgence and avoid the late summer holiday period. Allow for flexibility, such as a hiatus in the fieldwork timescales, to accommodate these.
- Engaged with industry bodies and business sample databases to expand the list of contacts, which may also assist in more targeted recruitment within businesses.
- Streamlined the survey, improving the description of questions or removing unnecessary questions, to improve response rates.
- Recognised the need to remind contacts to populate the survey and offer further channels for support in completing the survey, including virtual meetings through MS Teams and Zoom.

3.3.2 Technical Note 3.2

Technical Note 3.2 presented analysis based on the responses to questions in the pilot survey and recommendations to improve survey questions for work package 4.

The note reported that the value of goods were typically below £50,000 for each journey, and less than 10% of journeys involve transporting perishable goods. The pilot found that the average shipment cost for a single journey leg was £253. Respondents based this predominantly on typical transport costs such as fuel and staffing but other costs such as loading and insurance also featured. The cost per tonne per hour saw a large spread from £1 to upwards of £11.

On the profile of journeys, the note reported that typical shipments are subcontracted, and occur at regular intervals for which standard or contract fees are in place. All shipments were at the national level and most only involve a single transport leg.

In SP1 and SP2, respondents did not demonstrate a tendency to focus their choices on either the left or right alternative but respondents tended to select the cheap alternative relatively more frequently. The response patterns provided no indication of flaws in the experimental design and respondents were shown to be willing to make trade-offs between time and cost, and average time and reliability.

The resulting VTT and VTTR measures were higher than currently applied in the UK’s appraisal framework TAG, which reflects the literature on similar studies. The explanation for this was that the proposed method included additional cost components in addition to the staff time saved currently accounted for in TAG.

To improve the survey for work package 4, several questions were proposed to be streamlined, with some questions removed where the responses are unlikely to inform the report, and some were altered to improve the understanding and the quality of the response.

4. Survey

4.1 Survey design

The stated preference (SP) survey is set out in Appendix A.1. A summary is provided below. The questionnaire presented to respondents is shown in Appendix A.2.

The survey includes four areas of questioning; Section A which concerns the profile of the business, Section B relating to typical transport journeys made, Section C containing the SP scenarios, and Section D providing respondents with the opportunity to give feedback.

Concerning Section A and B, mandatory questions requiring responses consider:

- Company type (shipper / carrier (haulier) / own account).
- Value of goods (high / medium / low / perishable).
- Vehicle type: OGV1 (rigid vehicles over 3.5 tonnes with two or three axles), OGV2 (rigid and articulated vehicles over 3.5 tonnes with four or more axles) and LGVs (rigid light goods vehicles up to 3.5 tonnes).
- Routing direction (to port/ airport/ Channel Tunnel / rail interchanges/ not involving these).

The SP survey scenarios presents two choice experiments:

- SP1: a two-attribute experiment with time and cost, testing VTT.
- SP2: a three-attribute experiment with time, cost and reliability, testing VTTR.

Respondents are presented with a series of scenarios as illustrated in Figure 2.

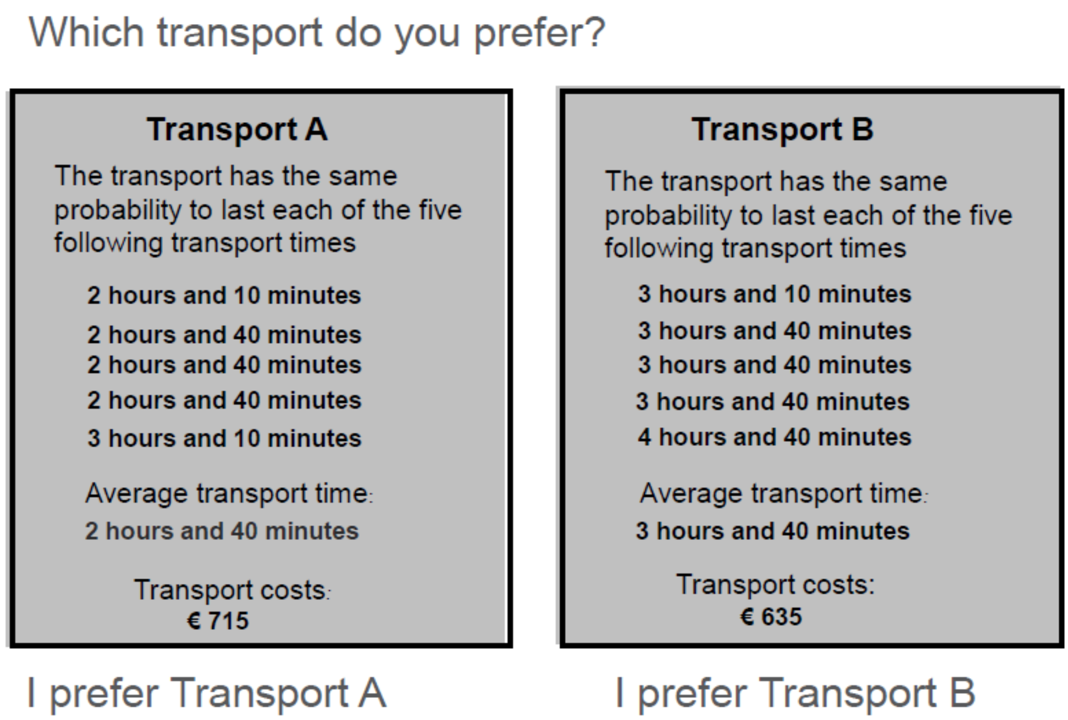


Figure 2: Example stated preference choice scenario

Work package 4 saw several questions removed concerning driver numbers, product stocks, and departure times which do not inform the analysis and increase the time required for a full response. Similarly, several questions were reworded to improve legibility. Further, scaling was corrected in SP2 where minutes had been presented as hours.

4.2 Outreach approach

For the main survey, a target of 600 interviews[4] was planned to achieve the required segmentation set out in Table 4.

All data collection was carried out in accordance with the Code of Conduct of the Market Research Society (MRS) which sets out requirements in respect to confidentiality of data and the responsibilities of the research agency to respondents and clients. Several members of the study team are members of the Market Research Society and thus pledged to uphold its standards.

4.2.1 Engaging businesses

When conducting the pilot study, 8% of all respondents contacted completed the survey, which was lower than expected. In order to achieve 600 responses, the minimum sample size was expanded by contacting industry bodies and purchasing a database of businesses from Experian. Further, the study engaged freight industry bodies to promote the study and communicate the merit of having more comprehensive values of travel time. The bodies engaged included:

- Chartered Institute of Logistics and Transport (CILT) including Freight and Logistics Policy Forum.
- Logistics UK.
- British Ports Association.
- UK Major Ports Group.
- Freight Council, facilitated by the Department for Transport.

In addition to expanding the sample and promoting the survey, the individual engagement approach of combining telephone interviews and online surveys was improved to encourage a higher response rate. The recruitment methodology was as follows:

- Interviewer to introduce the survey, build rapport and gain willingness to participate with the appropriate person from the organisation.
- Confirm eligibility of the business within agreed quotas.
- Search for the correct person in the business with an appropriate level of seniority to complete the survey and establish that they are engaged with the survey subject.
- Agree participation and confirm contact details of the preferred respondent.

Interviewers then made three attempts to establish telephone contact with each business unless an appointment was made, which required additional follow up calls to encourage participation.

It was important to contact the most appropriate person in the organisation who understood the nature of the project and was suitably qualified to gather required information to answer the survey questions. Transport or supply chain managers were targeted in the following types of company to complete the interview, subject to business size and type of organisation:

- Road Hauliers;(i.e. carriers).
- Shippers.
- In-house own account fleets who are both shippers and carriers.

For the purposes of this study, interviewers needed to complete the following tasks:

- Contact businesses to book appointments at a time that was convenient to the appropriate respondent and when they were on site, and confirm appointments the day before.

[4] This study is one of the largest so far undertaken in the world for a stated preference road haulage survey in this field.

- Report back to the project management team daily.

Interviewers received both a written and verbal briefing prior to starting work. The briefing included the following topics:

- Introduction and approach to businesses.
- Selecting the most appropriate respondent and navigating gatekeepers.
- Questionnaire knowledge and clarifications including a focus on the different scenarios.
- Checking the respondent had access to the information needed to complete sections of the survey.

The interviewing team used for the pilot also conducted interviews for the main survey to make use of their familiarity with the sector and content of the study.

4.2.2 Introductory text

The introductory text that the interviewer used was drafted and approved by the internal and external client team. This text was important for four reasons:

- It explained the project scope in concise terms that all organisations and employees would understand.
- It encouraged the respondent to take part and encourage them to see the benefits of taking part in the study.
- It assisted the interviewer to build up a rapport with the respondent and provide all the necessary information for any questions or queries the respondent had.
- It advised the potential respondent of the types of information they would need in advance, in order to complete the survey.

The text (in simpler format) was featured in the introduction to the online survey and the covering email so that the respondent could refer to it whilst completing the survey.

4.2.3 E-mail, inbox and online survey

Once a respondent had given their consent to take part in the online survey, emails with covering text and the survey link were sent out to the respondent within a maximum of 48 hours, less if possible (depending on weekends). Respondents then received up to three reminder emails and if they had still not completed it after the third email, then the interviewers followed up with one reminder call.

The survey platform (SNAP survey software) allowed for a unique link to be sent to each respondent and that meant we could track who had completed the survey, who had partially completed the survey and who was yet to start it. This allowed the AECOM team to track survey completion and target the correct respondents with reminders and follow up calls during the entire fieldwork period.

Also, within the email, there was a reminder to the respondents of what information they needed to have to hand in order to complete the survey. Again, this improved response rates and resulted in lower drop-out rates.

In addition to these options, a lesson learnt from the pilot was to have a specific project inbox set up for the project that was shared with potential respondents for a number of reasons:

- It gave them an email to contact should they have any queries on the survey as they completed it.
- It gave any warm leads or contacts who heard about the survey through other methods (e.g. Freight Council etc) a way of contacting the project team so they could be sent a unique link.
- The inbox was able to request unique links if more than one department at an organisation wanted to take part.

This inbox was monitored daily and any requests for links were responded to within 48 hours.

4.2.4 Face-to-face meetings

Study team staff also engaged with businesses face-to-face on Teams calls to encourage support to complete the survey and roll out interest to other departments and businesses connected to the contacts involved. This, for example, targeted the ports and maritime sector as a mid-survey review of respondents showed that this sector was under-represented. This technical input provided a significant increase in responses from this sector.

4.3 Sampling

For the main survey, we had a target of obtaining completed interviews from 300 shippers and 300 carriers. This allowed for a range of responses within each subsample, as required in Table 4, that were suitable for the SP survey. When recommending a sample size, the following factors had been considered:

- The subsamples within the wider sample needed to be statistically robust in order for the results to be useful when fed into the analysis stage and models.
- The quantity of sample and the location of businesses spread across the area.
- The anticipation that costs needed to be manageable.

As an SP survey, it was important for the sample size in this study to consider enough cases within each of the different subsamples of the sample. It was recognised from previous international studies that having around 300 responses in a particular sector was appropriate in obtaining a representative viewpoint. It was fully recognised that within this we needed to account for own account operators who act as both shippers and hauliers and some that sub-contract out just part of the transport operation.

4.4 Response rates

One of the key reasons to run a pilot survey was to understand the response rates of completion and the outcomes of engagement with the sample lists of companies so we could apply some logic to our expectations on the main survey. On the pilot survey, an 8% response rate was achieved from all contacts.

Table 6 shows the outcomes with the sample lists of companies and the overall response rate for completion.

Table 6: Main survey response rates

Response outcome	Frequencies (n)	Percentage (%)
Number of contacts	**16,224**	**100**
General refusals	1,429	9
Too busy – refusal	820	5
Not interested – refusal	520	3
TOTAL – Refusals	**2,769**	**17**
No contact	7,009	43
Incorrect number	224	1
Automated switchboard	124	1
TOTAL – No contact	**7,357**	**45**
Business no longer trading	65	0.4
Agreed to take part	6,033	37
Requested a link through Project Inbox	99	-
TOTAL – sent a unique link to complete	**6,132**	**38**
Completed the survey online	**602**	**10**

Over 16,000 companies were contacted, with over 6,000 agreeing to take part (37%), and 602 following through to complete the survey which resulted in a 10% response rate for the main survey from all contacts. The survey team engaged with respondents throughout the survey period to provide support and encourage completion of the survey. However, respondents noted that after initially showing interest and agreeing to participate, concerns were raised such as:

- Respondents were on annual leave and unable to complete the survey (the majority of the survey period took place during the summer holidays in July / August).
- General pressures on the workforce and operations meant that other aspects of the business were more important than a survey.

Of the 17% refusals, our interviewers, where possible, did probe to understand why the business was refusing to take part, so it was possible to understand if it was to do with their circumstances or the survey itself.

5% of respondents simply stated they were too busy at the time to take on completing the survey. Some of these companies, when probed further, referenced staff resource as a problem or that escalating costs on the business did not leave time to fill in the survey.

Others stated that it was a busy time of year in general, many staff were off for different periods of time on leave, so the workload was the main priority and again, they did not have time to complete the survey.

Some said they were not interested. Twenty said they were not interested because they did not see the benefit for them. This is likely to result from an unfamiliarity with how value of travel times inform policy. As such, sampling bias has not been identified as a risk for the analysis and has therefore not been tested for. Were sampling bias to arise, this would be resolved using representative weighted averages over segment specific VTT values using the population frequencies as the relevant weights.

4.5 Sampling profile

Of the companies that were contacted, 602 completed the survey online during the fieldwork. Over half (n=370) identified as carriers (Hauliers, see Table 7).

Table 7: Company type

Which of the following are you?	Frequency (n)	Percentage (%)
Haulier	370	62
Shipper who outsources ALL of their freight transport	88	15
Shipper who PARTLY outsources their freight transport (partially Own Account operation)	125	21
Shipper who does NOT outsource ANY of their freight transport (i.e. Own Account)	19	3
Total	602	100

The survey asked respondents the number of employees at the company, to understand its size. Table 8 shows that 38% of the companies have between 50 and 249 employees, 28% of the companies had 250-499 employees. Only 1% of the sample had less than 10 employees.

Table 8: Size of company (number of employees)

Number of employees	Frequency (n)	Percentage (%)
1-9	5	1
10-49	48	8
50-249	231	38
250-499	168	28
500-999	131	22
1000+	19	3
Total	602	100

All respondents were asked to state their region. Table 9 shows that the responses included companies from across the UK. Thirty percent of the companies were based in the South East whilst 26% were based in the North West of England, which partly reflects that some of the warm contacts came from the study team members based in the area, together with the fact that the North West is an industrial and distribution heartland. However these warm contacts were not from any previous work completed on value of time or related projects and therefore were no more aware of this work than other contacts.

Table 9: Region in which the company is based

Region	Frequency (n)	Percentage (%)
East Region	23	4
East and West Midlands Region	82	14
North West Region	156	26
South East Region (incl. London)	179	30
South West Region	59	10
Yorkshire and the North East Region	89	15
Scotland	9	2
Wales	5	1
Total	602	100

All companies were asked to think of a recent journey and then ask a range of questions on that specific journey. A comparison has been done between the companies and the commodities they were carrying with the DfT road freight statistics based on the CSRGT survey. The percentage is compared to both the tonnes and the tonne-kilometres travelled. A comment about whether the survey sample was low (i.e. under-sampling), about right (good) or high is included. Two categories have been combined for ease of reporting, waste and utilities as seen in Table 10 below.

Table 10: Product that was transported in the journey described in the survey, compared with DfT (2023a)

Product type	Frequency (n)	Percentage (%)	DfT Tonnage (%)	DfT Tonnes*km (%)	Survey
Agricultural (includes animal fodder/ livestock/ fertiliser)	15	3	6	7	Low
Automotive (includes finished vehicles and parts)	42	7	2	2	High
Building materials plus ores & aggregates	86	15	15	10	Good
Chemicals	17	3	3	4	Good
Coal	18	3	0	0	High
Food incl perishables and drink (includes tobacco)	87	15	14	18	Good
General Haulage (includes Groupage)	54	9	21	24	Low
Glass, cement, other non-metallic minerals	30	5	7	5	Good
Manufactured goods	220	37	1	1	High
Mail and parcels	76	13	2	3	High
Metals	30	5	2	2	High
Petroleum/ refined oil, coke	17	3	3	3	Good
Retail (non-food)	135	23	4	5	High
Utilities & Waste	55	9	13	8	Good
Total	**602**	**100**	**100**	**100**	**100**

A comparison was made between the CSRGT data, which was the latest available at the time of writing and covered the first period of stakeholder engagement and the FVTT / FVTTR sample at the industry sector level. A good correlation was achieved in six industry sectors mining/ores/aggregates, food, oil, chemicals, glass/cement, waste. There were several sectors reviewed that were either low (Agriculture, and General Haulage or high (Automotive, Mail / Parcels, Manufactured Goods, Metals and Retail).

For the low group, there may be a number of factors such as in these sectors that there are likely to be more small and medium sized enterprise (SME) hauliers, and others that might be classified as farmers and therefore not featured in the business database used. In general haulage, the average fleet size is about 6 vehicles and many of the smallest operators are not members of either of the road freight trade associations (although some may have been in the wider business database sample). The likelihood of gaining a response from a micro / one person business would be low as they are out driving most of the time, and slightly larger businesses may have no / small back offices, lower margin, less likely to be in a trade body.

For the high category, a different set of factors may have contributed. To varying degrees sectors such as automotive, parcels and retail are more time sensitive than the low categories, although not exclusively. These sectors tend to have higher values of the goods in transit than average including automotive and manufactured goods. In addition to the goods moved having a higher value, they tend to use larger logistics companies/hauliers. The consequence of that is these firms would be more likely to have larger structures and more staff time to be able to respond to the survey. These sectors are more likely to be in the highly road reliant sectors of the Strategic Road Network.

5. Analysis

5.1 Data cleaning

The analysis started with a sample of 602 completed surveys. With 8 choice responses in SP1 and 9 choice responses in SP2, a total 10,234 choices are recorded in the dataset. Table 11 describes an initial set of cleaning criteria where respondents reporting an empty shipment (weight =0), implied speed larger than the speed limit (60 mph), and a carrier not owning its own vehicles are excluded. A further data cleaning criteria removed 24 shippers working on their own account on the reference trip. The reason for this is that there were separate models for shippers and carriers. A remaining sample of 572 completed surveys (9,724 choices) was taken forward.

Table 11: Initial set of data cleaning criteria

	Number of completed surveys	Number of recorded choices*
Starting sample size	602	10234
Weight of shipment = 0	1	17
Speed > 60mph	4	68
Carrier not owning vehicle	1	17
Intermediate sample size	596	10132
Shippers shipping on own account	24	408
Final sample size (95.0%)	572	9724
* There were 17 choices per completed survey, 8 refer to SP1 and 9 to SP2		

Table 12 provides an overview as to how the 572 respondents were distributed across the different subsamples of interest (i.e. carriers vs. shippers, shipments (not) to port, and vehicle). The database comprised a total of 367 carriers and 205 shippers with a large representation of OGV1 vehicles not going to port.

Table 12: Number of responses for different vehicle types, destinations by shippers and carriers

		OGV2	OGV1	LGV	Total
Shippers	**To Port**	34	27	33	94
	Not to port	18	63	30	111
Carriers	**To Port**	52	50	24	126
	Not to port	45	145	51	241
Total		149	285	138	572

A further set of exclusion criteria were related to the responses made in the Stated Preference (SP) part of the survey and its follow-up question. Five exclusion criteria were considered:

1. **(C1) Removal of non-rational respondents**. In SP2, where respondents were requested to trade-off travel time, cost, and reliability, the final choice included a dominated alternative. That is, rational respondents were not expected to select this alternative, because it is slower, more expensive, and more unreliable than the other alternative. All respondents selecting the dominated alternative were excluded under this criterion.

2. **(C2) Removal of respondents not able to make sensible choices**. This exclusion criterion related to the responses to follow-up question D12, where respondents were asked if they were able to make sensible choices across all 17 choice tasks. All respondents answering 'no' were excluded under this criterion.

3. **(C3) Removal of respondents perceiving the journey attributes as either too high or too low.** This exclusion criterion related to follow-up question D14, where respondents were asked whether the presented journey characteristics were realistic (i.e. in terms of time, cost and reliability). All respondents answering 'no', for any of the three reasons provided, were excluded under this criterion.

4. **(C4) Removal of respondents perceiving the description of the journeys to be unclear.** This exclusion criterion relates to follow-up question D13, where respondents are asked whether the description of the journeys were clear. All respondents answering ‘no’ were excluded under this exclusion criterion.

5. **(C5) Removal of respondents accepting a very high boundary value of travel time (BVTT) in SP1.** Initial analysis of the SP choice data revealed that VTT values are coming out rather high. In terms of response behaviour, we found that in SP1 some respondents accept the highest BVTT presented to them despite it being set very high in the design specification. Since boundary values per tonne per hour were used in the design generation stage, we set the upper bound for carriers at £30 per tonne per hour and for shippers at £15 per tonne per hour. These values were based on empirical examination of the SP1 response data regarding the acceptance of the highest BVTT values whilst considering that shippers are presented with a smaller range of BVTT values due to the inherent characteristics of the empirical design.

Table 13 displays the impact of the five individual exclusion criteria on the remaining sample size. Besides checking the impact on the sample size, simple choice models were estimated to determine the impact of each exclusion criterion on the emerging VTT and VTTR values (see Appendix A.3 for results). For exclusion criteria C1-C4 the emerging VTT values for OGV1 and OGV2 are largely stable, whereas for LGV they increase slightly instead of coming down. For exclusion criteria C5, Table 3 reveals that for LGV vehicles in particular very high BVTT were accepted and removed by this exclusion criterion. Most notably, the VTT values for OGV1 and OGV2 vehicles were barely affected by C5 in the shippers’ cohort, since only two observations were removed. For carriers the VTT values are coming down for all vehicle types.

Based on these results, the following strategy was implemented. First, given the observed choice behaviour in the LGV sample and very high initial VTT values, it was decided to analyse this sample separately from the OGV1 and OGV2 samples. As a result of this split approach, all statistics were to be presented separately for OGV and LGV vehicles. Second, for both shippers and carriers C1 was implemented to ensure rationality of the sample. Third, for carriers – but not for shippers – C5 was implemented because it led to more plausible outcomes for carriers, whereas its impact on the OGV sample for shippers was limited. The final column of Table 13 shows the remaining sample size based on the selected exclusion criteria. Fourth, in the separate analysis of the LGV sample in Section 5.5, variations of C5 will be presented to determine a suitable VTT, but for the presented descriptive statistics in next section the described version of C5 (and C1) is applied.

Table 13: Impact of exclusion criteria on sample size

	Original sample size	Excluded observation C1	C2	C3	C4	C5	Final Excluded resp.	Remaining sample size
Shipper not to port OGV2	18	0	2	2	5	0	0	18
Shipper not to port OGV1	63	8	4	5	26	2	8	55
Shipper not to port LGV	30	2	2	2	13	10	12	18
Shipper to port OGV2	34	3	3	3	10	0	3	31
Shipper to port OGV1	27	1	3	5	4	0	1	26
Shipper to port LGV	33	1	9	9	17	10	11	22
Carrier not to port OGV2	45	5	5	7	17	2	6	39
Carrier not to port OGV1	145	12	7	9	40	12	23	122
Carrier not to port LGV	51	5	3	4	22	22	25	26
Carrier to port OGV2	52	2	7	7	14	3	5	47
Carrier to port OGV1	50	0	6	7	12	1	1	49
Carrier to port LGV	24	2	4	4	15	3	5	19
Total	**572**	**41**	**55**	**64**	**195**	**65**	**100**	**472**

With a total of 100 respondents removed, the main analysis was based on 130 OGV shippers and 257 OGV carriers, with their respective splits between vehicle types (OGV1 and OGV2) and trips (Not) To Port presented below in Table 14. For LGV the respective sample sizes are 40 and 45 for shippers and carriers.

Table 14: Sample sizes used for analysis in Section 5

		OGV1	OGV2	OGV	Total OGV	LGV	Total LGV
Shipper	**Not To Port**	55	18	73	**130**	18	**40**
	To Port	26	31	57		22	
Carrier	**Not To port**	122	39	161	**257**	26	**45**
	To Port	49	47	96		19	
Total		**252**	**135**	**387**		**85**	

5.2 Descriptive statistics: Typical transport journeys

Part B of the survey concerned shipments that were typical for the surveyed companies in terms of weight, packaging, distance, destination, etc. In this section, the responses to key questions are summarised.

Table 15 presents the types of goods transported when the respondents are considering a typical transport split out by vehicle type and shippers and carriers. The main types of goods transported were 'Manufactured goods' and 'Retail goods' for shippers, and additionally 'Mail and parcels' by carriers. Building materials were also well represented under shippers using LGV vehicles. Notably, when comparing Table 14 and Table 15 the totals display shippers on average transport 1.62 different types of goods per vehicle and carriers 1.40. As mentioned in Section 4, the obtained set of goods transported was not representative for the population. However, the modelling exercises presented below allow determination of whether the VTT and VTTR for well-represented goods categories differed from the other goods transported. These results were then used to arrive at a representative VTT and VTTR to be used for appraisal purposes.

Table 15: Types of goods transported when taking a typical transport into account

	OGV		LGV		Total	
	Shippers %	Carriers %	Shippers %	Carriers %	Shippers %	Carriers %
Agricultural	1%	2%	3%	0%	1%	1%
Automotive	9%	3%	8%	0%	9%	3%
Building materials	6%	4%	11%	6%	7%	4%
Chemicals	1%	2%	3%	6%	2%	3%
Coal	0%	3%	2%	3%	0%	3%
Food and drink	3%	5%	6%	2%	4%	4%
General haulage	2%	8%	2%	5%	2%	8%
Glass, cement	5%	2%	2%	3%	4%	2%
Manufactured goods	32%	20%	31%	23%	32%	21%
Mail and parcels	3%	11%	5%	12%	4%	11%
Metals	5%	2%	5%	0%	5%	2%
Ores	4%	2%	3%	6%	4%	2%
Perishable goods	9%	5%	6%	2%	9%	5%
Petroleum	0%	3%	5%	0%	1%	3%
Retail	16%	16%	9%	23%	14%	17%
Utilities	1%	7%	0%	6%	1%	7%
Waste	0%	4%	0%	3%	0%	4%
Other	0%	0%	0%	0%	0%	0%
Total	211	357	64	65	275	422

Table 16 and Table 17 below highlight that for OGV shippers and carriers shipments were primarily transported from production facilities and distribution warehouses to customers business premises, port/ferry terminals and airports. A closer examination of the shipments being part of a larger transport chain, reveals that this variable correlates with whether the trips were going to a port (sea, rail, airport). Only three shipments covered a linking of multiple legs using road vehicles. Respectively 64% and 65% of port related trips are associated with sea shipping for shippers and carriers. For LGV type vehicles only a handful of shipments went to respectively rail- and airports. For OGV we find the following split for Sea shipping 60% (61%), Rail 12% (18%), and Air 29% (21%) for shippers (carriers).

Table 16: OGV Shippers - Facilities from which and to the shipments are transported

From / To:	A	B	C	D	E	F	G	Total
Airport	0	0	1	0	0	0	0	1
Distribution warehouse	2	2	13	0	15	1	0	33
Port/ferry terminal	0	0	0	0	0	1	0	1
Production facility	15	0	43	1	23	6	7	95
Rail cargo terminal	0	0	0	0	0	0	0	0
Other	0	0	0	0	0	0	0	0
Total	**17**	**2**	**57**	**1**	**38**	**8**	**7**	**130**

A – Airport
B – Channel Tunnel
C – Customer Business premises
D – Customer Household premises
E – Port/ferry terminal
F – Distribution warehouse
G – Rail cargo terminal

Table 17: OGV Carriers - Facilities from which and to the typical transports are transported

From / To:	A	B	C	D	E	F	G	H	Total
Airport	0	0	0	0	0	0	0	0	0
Distribution warehouse	4	0	23	1	24	0	1	0	53
Port/ferry terminal	0	0	1	0	0	0	0	0	1
Production facility	14	0	121	0	54	6	4	2	201
Rail cargo terminal	0	0	1	0	0	1	0	0	2
Other	0	0	0	0	0	0	0	0	0
Total	**18**	**0**	**146**	**1**	**78**	**7**	**5**	**2**	**257**

A – Airport
B – Channel Tunnel
C – Customer Business premises
D – Customer Household premises
E – Port/ferry terminal
F – Distribution warehouse
G – Rail cargo terminal
H – Other

Table 18 shows that, where information is available, most of the typical transports were occurring less than once a week or at most a couple of times per week. In terms of packaging, both OGV and LGV transports largely made use of ‘boxes / packages / pallets’ and ‘dry / wet bulk’. OGV shippers and carriers made use of containers in roughly 25% of the transports, and in about 10% of the cases they made use of temperature-controlled vehicles (Table 19).

Table 18: Frequency of the typical transports

	OGV		LGV	
	Shippers	Carriers	Shippers	Carriers
5+ a week	6%	12%	8%	9%
3-4 times a week	12%	5%	5%	11%
1-2 times a week	17%	9%	25%	16%
Less than once a week	36%	39%	25%	49%
One-off	11%	16%	5%	0%
NA	18%	19%	33%	16%

Table 19: Packaging of transports

	OGV		LGV	
	Shippers	Carriers	Shippers	Carriers
Boxes / packages / pallets	35%	40%	38%	49%
Dry / wet bulk	49%	45%	40%	62%
Temperature controlled transport	10%	11%	0%	18%
Containers	28%	23%	8%	20%
Other	0%	0%	0%	0%
NA	18%	21%	53%	18%

Table 20 provides summary statistics for the distance, total time and total costs associated with the typical transport. Table 20 highlights there were no illogical outliers in terms of distance, transport time or transport cost in the data. As to be expected, LGV journey were shorter in distance and were accordingly associated with shorter transport times, and transport costs. The size of the vehicle also influenced the total transport costs indicating lower transport costs for LGV vehicles. Comparing the sample of OGV1 and OGV2 typical transport journeys, the mean distance was comparable for shippers, but the median distance for OGV1 was much higher than its OGV2 counterpart. For carriers, OGV2 journeys were much longer compared to its OGV1 counterpart and accordingly its travel time and travel costs were higher. A fairer comparison is to look into the total transport costs per hour. In this instance, one would expect to see the following order of magnitude (OGV2>OGV1>LGV) because of the size of depreciation on the vehicle and the need for more specialised drivers with increasingly large vehicles. Reported transport costs for OGV1 were, however, consistently higher than for LGV, and OGV2 transport costs were relatively low. As noted before, such patterns may not be representative for the actual travelling population, but as long as the spread in travel times, distance and costs in the data are appropriate, corrections can be made after analysis if evidence is found that the VTT and VTTR vary by time distance and (or) cost using their respective elasticities.

Table 20: Overview of distance, time and cost associated with the typical transport

		OGV1		OGV2		LGV	
		Shippers	Carriers	Shippers	Carriers	Shippers	Carriers
Distance (miles)	**Mean**	60.54	54.04	60.9	84.03	36.08	35.22
	Std.Dev	45.26	45.4	70.22	61.58	38.77	22.86
	Min	7	5	7	8	7	3
	Median	50	40	35	64	21	30
	Max	230	230	450	300	200	120
Time (minutes)	**Mean**	105.46	98.25	123.39	160.1	70.4	66.64
	Std.Dev	71.01	77.08	108.82	107.02	58.93	39.71
	Min	11	10	25	10	25	12
	Median	90	75	90	120	47.5	50
	Max	385	375	705	505	310	190
Cost (£)	**Mean**	132.33	120.36	117.06	179	77.88	69.38
	Std.Dev	101.18	99.36	112.38	135.52	86.39	44.26
	Min	16	13	23	21	15	22
	Median	100	90	70	147.5	45	58
	Max	520	500	508	680	500	250
Cost per hr (£)	**Mean**	74.75	74.84	55.01	66.49	64.54	66.56
	Std.Dev	20.43	19.1	21.87	20.16	21.86	20.45
	Min	36.67	28.42	25.26	31.2	24	38.4
	Median	77.78	76.00	51.43	66.59	59.23	67.06
	Max	140	143.18	169.33	156.92	100	110

Table 21 gives more detail on the time and cost components included for each typical transport. All responses included driving time and standard transport costs (fuel, personnel, depreciation, maintenance, admin). Most responses included loading and unloading time whereas extra travel time is included by 70-90% of firms and OGV2 had a slightly higher share in this, probably due to the longer journeys. Similarly, loading and unloading of the cargo at origin and destination of the transport was most often included. Table

22 reports the summary statistics of the length of the different time components in minutes, this decomposition is not available for the cost components. In the remainder of the report the total transport times and transport costs including all listed components are used.

Table 21: Included time and costs components by vehicle type

	OGV1		OGV2		LGV	
	Shippers	Carriers	Shippers	Carriers	Shippers	Carriers
Time components						
Loading time	93%	95%	98%	98%	98%	98%
Driving time	100%	100%	100%	100%	100%	100%
Extra travel time (e.g. congestion, roadworks)	78%	72%	90%	87%	73%	78%
Rest breaks	9%	11%	8%	19%	3%	0%
Unloading	95%	94%	96%	98%	93%	96%
Cost components						
Transport costs	100%	100%	100%	100%	100%	100%
Transport costs for other means of transport used for the same transport	5%	4%	2%	4%	3%	7%
Insurances for loss or damage of freight	16%	20%	10%	16%	11%	16%
Possible penalty fees (for example, imposed by client)	15%	10%	17%	7%	3%	13%
International freight fees	16%	11%	4%	4%	11%	0%
Custom duties	1%	4%	2%	4%	3%	9%
Loading at origin	59%	83%	71%	76%	79%	78%
Unloading at destination	65%	81%	73%	73%	82%	76%
Transhipments at intermediate locations	5%	2%	0%	0%	0%	0%
Other costs	2%	1%	0%	1%	0%	0%

Table 22: Summary statistics on time components in minutes

	OGV1		OGV2		LGV	
	Mean	St. dev	Mean	St. dev	Mean	St. dev
Time components (minutes) - Shippers						
Loading time	7.41	4.57	13.69	9.60	5.88	4.44
Driving time	78.48	56.48	81.86	91.22	50.48	45.41
Extra driving time (e.g. congestion, roadworks, diversions)	6.51	6.10	7.84	6.10	5.22	8.47
Rest breaks	2.96	10.48	3.67	12.82	0.75	4.74
Unloading	10.10	6.87	16.33	10.79	8.07	8.12
Time components (minutes) - Carriers						
Loading time	8.21	7.58	14.97	11.26	6.16	5.13
Driving time	71.43	57.80	109.22	77.78	47.38	29.87
Extra driving time (e.g. congestion, roadworks, diversions)	6.09	6.65	10.14	8.81	4.11	3.59
Rest breaks	3.57	11.20	8.49	18.38	0.00	0.00
Unloading	8.95	8.14	17.29	11.54	9.00	8.87

5.3 Descriptive statistics: Responses

In Part C of the SP survey, the respondents are presented with two distinct SP experiments, SP1 and SP2. The response patterns to SP1 are examined before discussing SP2 in more detail.

In SP1 the respondents were presented with eight choice scenarios (or choice tasks). In each of these choice tasks two scenarios were displayed on the screen describing the transport time and transport cost for the ‘typical’ transport, as described in Part B of the SP survey. The presented levels of transport time and transport cost were variations around the reported transport time and costs for the typical transport (as summarised in Table 20 and Table 21). These variations were based on the experimental design as presented in Appendix A.1. One of the two scenarios was characterised as the ‘cheap but slow’ option, displaying lower transport costs but higher transport times than the other ‘fast but expensive’ scenario. In Figure 3 below, an example of such a choice card was presented where option A is ‘fast but expensive’ and option B is ‘cheap but slow option’.

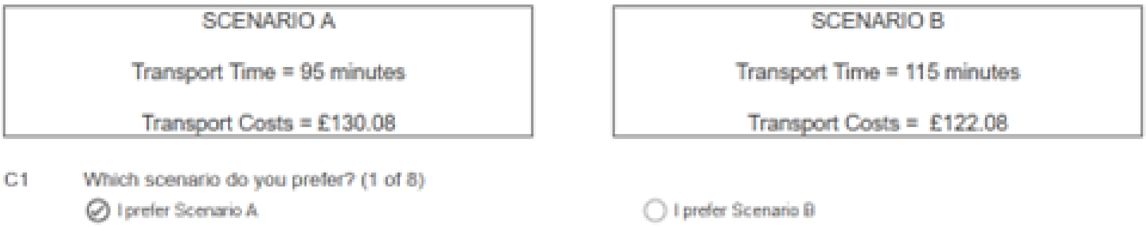


Figure 3: Example of a choice card in SP1

Implicit in each of the choice cards in SP1 is what is known as the ‘Boundary Value of Transport Time’ (BVTT). That is, by taking the ratio of the cost difference between the two scenarios over the ratio to transport time differences, the presented value of transport time per minute can be inferred. If the respondent is willing to pay more than this BVTT, it is assumed he (or she) will select the fast but expensive option, if (s)he is not prepared the BVTT it is assumed that the respondent will select the cheap but slow alternative. Since the presented values for transport time and transport costs vary across the eight choice cards, insights into how the respondents VTT relates to the presented BVTT are obtained.

Table 23 shows that in the dataset there was a tendency to select the fast and expensive scenario in SP1 and this feature is shared across the different vehicle types. Most respondents select the fast and expensive alternative at least four out of eight times. It is only the carriers using OGV2 types of vehicles who were more inclined to select the cheap but slow alternative. Shippers were in general more drawn towards the fast but expensive alternatives compared to their carrier counterparts using the same vehicle type and this tendency increased as the size of the vehicle type decreased. Part of this may be driven by experimental design differences, since presented transport costs and times were varied based on the specifics of shippers/ carriers and the used vehicle type, but the presented variation in the BVTT within each of these subsamples was sufficiently large to counteract at least some of these effects. Remarkable are the high shares for ‘non-traders’ that always (i.e. eight times) selected the fast and expensive alternative for LGV and OVG1 shippers, and LGV carriers, since these respondents indicate their VTT was effectively above the highest presented BVTT and this will eventually drive up the VTT estimates for these subsamples.[5]

[5] Please note that all presented statistics are after the data cleaning described in Section 5.1 has been applied.

Table 23: Number of times the fast and expensive alternative was chosen in SP1 by vehicle type

Times Fast and Expensive chosen	OGV1 Shippers		Carriers		OGV2 Shippers		Carriers		LGV Shippers		Carriers	
0	0	0%	1	1%	1	2%	12	14%	0	0%	0	0%
1	0	0%	11	6%	0	0%	20	23%	0	0%	1	2%
2	1	1%	25	15%	0	0%	33	38%	0	0%	0	0%
3	2	2%	29	17%	3	6%	12	14%	2	5%	1	2%
4	8	10%	34	20%	10	20%	5	6%	1	3%	2	4%
5	9	11%	37	22%	6	12%	2	2%	0	0%	3	7%
6	17	21%	18	11%	12	24%	1	1%	6	15%	6	13%
7	20	25%	11	6%	12	24%	1	1%	13	33%	19	42%
8	24	30%	5	3%	5	10%	0	0%	18	45%	13	29%

Table 24 dives a bit further into the SP1 response patterns and provides the reassuring picture that as the presented value of the BVTT increased, the share of respondents selecting the 'fast and expensive option', i.e. accepting the BVTT decreased. That is, when one must pay more for reductions in transport time the share of respondents willing to do so would reduce. The high shares for LGV and OVG1 shippers, and LGV carriers confirm the picture described in Table 23 of a high tendency to accept the high BVTT value. Compared to other freight and passenger VTT studies, these acceptance shares for these three categories are high.

Table 24: Share of respondents accepting the BVTT by rank

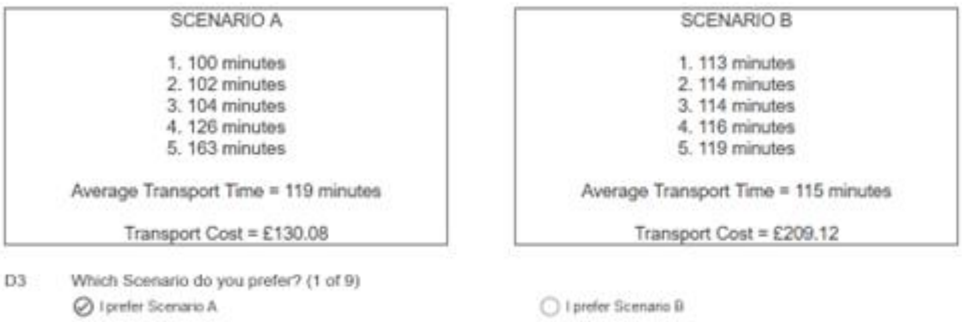
	OGV1 Shippers	Carriers	OGV2 Shippers	Carriers	LGV Shippers	Carriers
Accept lowest bid	96%	88%	90%	70%	95%	96%
2nd lowest bid	89%	80%	92%	44%	93%	93%
3rd lowest bid	94%	65%	94%	38%	85%	93%
4th lowest bid	91%	56%	86%	16%	85%	89%
4th highest bid	80%	43%	71%	8%	95%	89%
3rd highest bid	72%	34%	61%	8%	85%	80%
2nd highest bid	67%	25%	45%	3%	98%	78%
Accept highest BVTT	52%	15%	22%	3%	68%	49%

Table 25 provides more insights into the average presented BVTT values by rank by segment of interest. The presented choice tasks and implicit BVTT values originate from an experimental design. The experimental design used the self-reported transport costs and travel times for the reference transport as the reference point. Positive and negative variations in transport costs and travel times were presented around these reference values. The ranges in transport costs and travel times were based on existing knowledge of VTT values obtained in similar SP studies in the international literature, but also present more extreme values to accommodate for respondents with a high VTT values, especially by presenting very high BVTT values for the highest presented BVTT (nearly doubling relative to the 2nd highest bid). The empirical literature suggested that VTTs for shippers were lower than carriers, and hence shippers are presented with lower BVTT values. Similarly, the VTT was expected to increase with the size of the vehicle (due increased costs of drivers and depreciation etc.) and the design therefore presented higher BVTT values for larger vehicles. The designs were tested in the pilot, during which the rate of accepting the highest BVTT values was not as extreme as in the present sample. The relative differences between shippers and carriers in presented BVTT values (a factor 5-6) may explain the discrepancies across shippers and carriers. However, the observed response patterns appear a specific feature of the sample, for which we do not have a clear explanation.

Table 25: Average presented BVTT (£ per hr) by rank

	OGV1		OGV2		LGV	
	Shippers	Carriers	Shippers	Carriers	Shippers	Carriers
Lowest bid	£ 2.87	£ 18.29	£ 6.75	£ 36.20	£ 0.79	£ 3.15
2nd lowest bid	£ 4.75	£ 30.29	£ 11.19	£ 59.50	£ 1.43	£ 5.58
3rd lowest bid	£ 7.02	£ 44.95	£ 16.31	£ 89.04	£ 2.16	£ 8.37
4th lowest bid	£ 11.50	£ 69.87	£ 27.28	£ 146.48	£ 3.54	£ 13.43
4th highest bid	£ 20.11	£ 111.57	£ 49.04	£ 223.23	£ 5.71	£ 19.44
3rd highest bid	£ 34.62	£ 182.48	£ 79.79	£ 369.99	£ 8.68	£ 30.50
2nd highest bid	£ 56.26	£ 307.01	£ 127.11	£ 594.79	£ 14.36	£ 52.59
Highest BVTT	£ 124.66	£ 697.58	£ 269.02	£1,197.86	£ 28.66	£ 100.47

In SP2 respondents were presented with a similar set of scenarios in each choice card, but the new factor of transport time reliability was added into the mix. Transport time was presented by five equiprobably transport times - which were drawn from an underlying distribution with a known standard deviation - and an average transport time. The presentation was completed with the corresponding transport costs. An example of a choice card is presented in Figure 4 where scenario B is quicker, on average, and is more reliable due to the lower variation in transport time, but it also costs more.


SCENARIO A

1. 100 minutes
2. 102 minutes
3. 104 minutes
4. 126 minutes
5. 163 minutes

Average Transport Time = 119 minutes

Transport Cost = £130.08

SCENARIO B

1. 113 minutes
2. 114 minutes
3. 114 minutes
4. 116 minutes
5. 119 minutes

Average Transport Time = 115 minutes

Transport Cost = £209.12

D3 Which Scenario do you prefer? (1 of 9)

I prefer Scenario A

I prefer Scenario B

Figure 4: Example choice card for SP2

Since respondents were now trading-off on three attributes in each of the nine choice tasks presented, the concept of the BVTT did not apply to SP2. Additional costs can be attributed to reducing average transport time or its reliability (i.e. standard deviation). The frequency by which respondents selected one of the three attributes can still be examined. Noteworthy here is that in choice tasks 1-4 of SP2 the transport costs were the same and the respondents were trading-off travel time and reliability. This explains why in Table 26 below, respondents can only select the cheapest alternative a maximum number of five times.

Again, transport time was the most prominent trigger of behaviour and particularly shippers were tending to select the fastest alternative in most choice situations as opposed to focusing on alternative response strategies based on the cheapest or most reliable alternative.

Table 26: Response patterns in SP2

		Shippers			Carriers		
Vehicle	Times selecting	Most reliable	Fastest	Cheapest	Most reliable	Fastest	Cheapest
OGV1	1	0%	0%	22%	0%	1%	6%
	2	11%	0%	41%	8%	4%	23%
	3	26%	1%	22%	22%	9%	31%
	4	27%	1%	14%	26%	12%	31%
	5	23%	11%	1%	17%	19%	8%
	6	2%	15%		9%	14%	
	7	6%	21%		8%	20%	
	8	4%	19%		6%	18%	
	9	0%	32%		4%	4%	
OGV2	1	1%	0%	10%	2%	1%	2%
	2	9%	0%	21%	4%	2%	8%
	3	12%	0%	16%	8%	7%	11%
	4	16%	4%	11%	9%	6%	14%
	5	10%	10%	2%	15%	11%	16%
	6	7%	10%		3%	10%	
	7	5%	9%		4%	8%	
	8	0%	12%		6%	3%	
	9	0%	16%		1%	1%	
LGV	1	0%	0%	15%	0%	0%	13%
	2	0%	0%	60%	9%	2%	42%
	3	23%	0%	23%	7%	4%	36%
	4	30%	5%	3%	24%	18%	9%
	5	13%	5%	0%	11%	22%	0%
	6	18%	20%		9%	18%	
	7	18%	25%		24%	13%	
	8	0%	30%		9%	18%	
	9	0%	15%		7%	4%	

The nineth choice task of SP2 related to exclusion criterion C5 (see Section 5.1). As a result, no respondent in this choice task selected the dominant alternative, which was more expensive, but also slower and more unreliable at the same time. Accordingly, no respondent selected either of the three attributes zero times. In the full sample 7% selected the dominant alternative and these are excluded due to the non-rationality of this decision as per C5.

As a follow-up to the SP part of the survey, respondents were asked about the extent to which they i) were able to make sensible choices, ii) believed the presented journeys were realistic and iii) the journey descriptions were clear. The responses to these questions are summarised below in Table 27. Since these responses were not mandatory, a relatively high share of NA responses was registered. Nevertheless, most respondents were able to make sensible choices and believed that the presented journeys were realistic. Only in a limited number of cases did respondents believe that the variation in travel times was too high or too low. This was less the case for the presented travel times and only two respondents believed the presented transport costs were too high or too low. It is therefore unclear why most respondents indicated that the journey description was unclear. All three follow-up questions have been included as part of the exclusion criteria checks. As port of these checks their impact on the VTT was examined. As previously noted, respondents answering ‘No’ to these questions were removed, and a test to reintroduce them suggested that this was not of significant impact. For the final question (D14), referring to the clarity of describing the journeys, the impact on sample size was also considered to be large.

Table 27: Overview of responses to the follow-up questions to the SP component

	OGV1		OGV2		LGV	
	Shippers	Carriers	Shippers	Carriers	Shippers	Carriers
Sensible choices (D12)						
Yes	48	117	27	59	20	32
No	7	11	5	10	8	4
NA	26	43	17	17	12	9
Realistic journeys (D13)						
Yes	45	114	27	57	20	32
No, travel times were too high / low	4	5	1	6	4	4
No, variation in travel times was too high / low	10	13	5	10	8	4
No, travel costs were too high / low	0	0	0	2	0	0
NA	26	43	17	17	12	9
Clear journey descriptions (D14)						
Yes	10	21	6	16	2	2
No	25	46	14	29	21	25
NA	46	104	29	41	17	18

5.4 Modelling approach

In this subsection the different model types used to analyse the choice data generated by SP1 and SP2 are described. As mentioned in Section 5.1, the analysis was conducted separately for OGV (combining OGV1 and OGV2 data) and LGV, due to the high VTT values emerging for the LGV sample in initial analysis. The structure of the choice models did not change between the OGV and the LGV samples.

The modelling took its inspiration from the 2014/15 UK passenger VTT study (Hess et al. 2017). Firstly, joint models for the choices made in SP1 and SP2 were estimated. Secondly, any variation in the VTT (and VTTR) of interest were modelled as deviations of the base VTT using multipliers. The latter approach helped significantly in controlling the number of parameters in estimation.

5.4.1 Random utility, random valuation, and relative choice models

Three different type of model specifications were contrasted to arrive at the final model specification. Each of these three specifications is discussed in more detail below.

- Random Utility Maximisation (RUM) in willingness to pay (WTP) space.
- Random Valuation (RV).
- Relative Models.

Random utility maximisation (RUM) in WTP space

McFadden's (1974) RUM framework assumed that decision makers are utility maximisers and that they will select the alternative generating the highest level of indirect utility V. In SP1 and SP2 the alternatives relate to the presented Scenarios A and B respectively. Accordingly, respondents would select Scenario A over Scenario B when $V_A \geq V_B$, and Scenario B over Scenario A when $V_A < V_B$. The attractiveness of each scenario is thus described by the utility function for alternative j.

The simplest application of the RUM would be to work in 'utility space' and specify V_j by:

$$V_j = ASC_j + \beta_{TT} \cdot TT_j + \beta_{SD} \cdot SD_j + \beta_{TC} \cdot TC_j + \epsilon_j$$

Where:

- ASC_j denotes an alternative specific constant for alternative *j* – possibly accounting for left/right biases in response patterns. For identification purposes one of the ASCs needs to be normalised to zero.

- β_{TT} represents the marginal (dis)utility of transport time. Due to the opportunity costs of transport time this coefficient is expected to be negative.

- TT_j captures the transport time in minutes associated with alternative *j*

- β_{SD} represents the marginal (dis)utility of the standard deviation of transport time. Due to the uncertainty introduced by unreliable travel times this coefficient is expected to be negative.

- SD_j captures the standard deviation of travel time (in minutes) of alternative *j*

- β_{TC} represents the marginal (dis)utility of travel cost. Due to the opportunity costs of travel cost this coefficient is expected to be negative.

- TC_j captures the travel costs in GBP associated with alternative *j*

- ϵ_j represents an error term following an extreme value Type 1 distribution such that binary logit type choice probabilities emerge.

Within the above context, the probability that Scenario A is selected in the binary choices used in SP1 and SP2 can be described by:

$$P(Y = A) = \frac{\exp(V_A)}{\exp(V_B) + \exp(V_B)}$$

After estimation, the VTT, the VTTR and the reliability ratio (RR) can be derived using:

$$VTT = \frac{\beta_{TT}}{\beta_{TC}}$$

$$VTTR = \frac{\beta_{SD}}{\beta_{TC}}$$

$$RR = \frac{VTTR}{VTT}$$

Train and Weeks (2005) proposed an alternative formulation of the above RUM model in ‘WTP space’ allowing the direct estimation of the VTT and VTTR of interest. The specification requires a simple modification of the indirect utility function such that:

$$V_j = \mu \cdot \left(ASC_j - VTT \cdot TT_j - VTTR \cdot SD_j - TC_j\right) + \epsilon_j$$

Where:

- μ represents the negative of the original cost coefficient β_{TC}, but because it is also a multiplier with the observed part of the utility function it is also perfectly confounded with the scale of the logit model and the two aspects cannot be separated.

- VTT and $VTTR$ are now directly estimated in the model and associated with a negative sign to ensure that increases in travel time and reductions in reliability (i.e. increases in the standard deviation of transport time) reduce utility.

Since the RUM model in WTP space is only a reformulation of the original model the RUM model in ‘utility space’ the results are identical.

Random valuation

The RV model is only relevant in relation to SP1, because it revolves around the notion of the BVTT (see Cabral et al. 2016). The RV model, namely, describes the utility for the 'fast but expensive' (FE) and 'cheap but slow' (CS) alternatives, instead of Scenario A and Scenario B.

Define V_{CS} and V_{FE} as the corresponding utility functions for the two options in SP1, where:

$$V_{CS} = BVTT + \epsilon_{CS}$$

$$V_{FE} = VTT + \epsilon_{FE}$$

In the RV model, the respondent was assumed to select FE only when their VTT was higher than the presented boundary value of time, i.e. when $V_{FE} > V_{CS}$ and choice probabilities were derived in the same vein for the RUM model. Since the utility functions under RV were directly expressing the BVTT and the VTT they are in 'valuation space'.

Later, Cabral et al. (2016) presented an extensive discussion as to how the RV and RUM model relate. The most important distinction is the treatment of the error term. In the RV model, the variance of the VTT was constant, whereas under the RUM approach, the variance of the VTT is proportional to the travel time. The choice for the RUM or RV model is empirical and subject of investigation in Section 5.5.[6]

The relative model

Both the RUM and the RV models are absolute models, since their utility or value functions contain attributes measured in an absolute way, i.e. in number of pounds, number of hours, etc. Another specification that can be used is the relative model. Such models were used in the Dutch freight VTT studies of 1992 (Hague Consulting Group et al., 1992), 2003/2004 (RAND Europe et al., 2004) and 2009-2013 (Significance et al., 2013; de Jong et al., 2014) to cope with the heterogeneity in the typical transports in the SP data.

In a relative model, all attributes are expressed as ratios relative to their base value. In this study, the base values related to the transport cost and time of the typical transport reported in Section B of the survey. Only for the standard deviation of travel time, a constant base value of 20 minutes was selected, since this information was not available from the survey for the typical transport. The choice of the latter base value was arbitrary but did not influence the modelling results because it did not vary across respondents. The base values for transport time and costs, however, differed across respondents and therefore the results from the relative model differed from the RUM model.

The utility function for each alternative *j* for a given respondent *n* in the relative modelling framework looks like

$$V_{jn} = \beta_{TC}^{rel} \cdot \frac{TC_{jn}}{TC_n^{base}} + \beta_{TC}^{rel} \cdot \frac{TT_{jn}}{TT_n^{base}} + \beta_{TC}^{rel} \cdot \frac{SD_{jn}}{SD^{base}} + \epsilon_{jn}$$

where:

TC_n^{base} = Base value of the travel or transport cost (BaseCost) for respondent *n*

TT_n^{base} = Base value of the travel or transport time (BaseTime) for respondent n

SD^{base} = Base value of the standard deviation of the travel or transport time distribution

The relative model removed the variation in the attribute values between respondents (e.g. all costs in the relative model become values centred around 1 for all respondents). This means that the coefficients were estimated solely on the variations offered in the SP experiments. This removed potential problems caused by the potentially enormous variation in attribute values between respondents in freight. It can also be a disadvantage not to make use of absolute attribute variation between respondents.

[6] Implementation of the RV model in our joint estimation of SP1 and SP2 requires combining the RUM in WTP space and the RV approach as discuss in more detail in Appendix A.1.

The ratio of the estimated transport time coefficient to the estimated transport cost coefficient could be treated as a trade-off ratio that indicates how relative changes in time are traded off against relative changes in costs.

$$TR = \frac{\beta_{TT}^{rel}}{\beta_{TC}^{rel}}$$

By multiplying this ratio by the transport cost per hour for a mode (or vehicle type within a mode), the so-called 'factor costs', we obtain the VTT (and similarly the VTTR):

$$VTT = TR \cdot FactorCost$$

The factor cost can come from some external source, such as standard transport cost calculations for the freight sector by mode or vehicle type. The TC_{jn} variable corresponding to the parameter for transport cost β_{TC}^{rel} captures all relevant cost components included in the transport costs reported for the typical transport (see Table 21 for summary statistics) and accordingly the definition of the factor costs should be as complete as possible or at least include the cost components most frequently reported for the typical transport (transport costs and costs for loading and unloading the vehicle). The relative model formulation is only defined for the random utility framework and cannot be used in the random valuation framework.

5.4.2 Additive and multiplicative error terms

The utility (or value) functions from Section 5.4.1 all used additive error terms. In recent years an alternative form, multiplicative error terms, is increasingly applied in the VTT literature, including the 2014/15 UK passenger VTT study (Fosgerau and Bierlaire 2009, Hess et al. 2017). Multiplicative models assume that as the size of utility (or value) increases, the variance of the error term grows accordingly. This makes intuitive sense when considering longer transport journeys (or (B)VTTs). Alike the choice of model type (RUM, RV or relative), the choice for the appropriate error structure (additive or multiplicative) would be entirely empirical and there would be no theoretical reason to favour one model specification over the other. The choice of model specification is therefore the subject of investigation in Section 5.5 below, and Appendix A.4 provides more information on the shape of the functional forms under additive and multiplicative error terms.

5.4.3 Joint estimation of SP1 and SP2 models

Joint models were estimated for SP1 and SP2 using the following approach. Since additional attributes were included in SP2, it was important to control for potential scale differences between SP1 and SP2. A second potential source of variation between SP1 and SP2 was that the VTT and VTTR could have been different across the two SP games; this was treated in the same way observed heterogeneity in Section 5.4.4 below.

Where in SP1 there was a choice between RUM, RV and Relative models, for SP2 the choice is only between RUM and Relative models. When estimating RV models, this implies combining the RV model for SP1 with the RUM model in WTP space for SP2. This was possible because both models directly estimated the same parameters of interest, i.e. VTT and the VTTR etc. The only thing the analyst needs to be careful about is that when combining the RV (SP1) and RUM models in WTP space (SP2) is that the definition of the alternatives captured by the utility functions will change accordingly from FE and CS in SP1 to Scenario A and B in SP2. A full detail on the estimated functional forms is provided in Appendix A.4.

5.4.4 Heterogeneity in the VTT and VTTR measures

We distinguish between observed and unobserved heterogeneity in the VTT(R) as follows.

Observed heterogeneity in the VTT(R) related to interacting the VTT(R) with variables in the database that were believed to influence the VTT(R), these related to the characteristics of the firm, the journey characteristics, including the vehicle characteristics and the goods transported. By jointly analysing shipments made by OGV1 and OGV2, the VTT(R) will accordingly be multiplied by a scalar γ_{OGV2}. More specifically, $VTT_{OGV2} = \theta \cdot \gamma_{OGV2}^{\delta_{OGV2}}$ where a baseline VTT is represented by θ, in this case the VTT for OGV1 trips. When a shipment would be done using OGV2 then the dummy variable δ_{OGV2}would take the value of 1 (and 0 otherwise). A multiplier larger than 1 indicates that the VTT for OGV2 would be higher than for OGV1. A range of different dummy variables was implemented to see if they influence the VTT, including the distinction between SP1 and SP2 described above, and the different commodity types transported. In addition to dummy variables, a set of elasticities related to the distance, time and cost of the typical shipment were estimated. The VTTR was also treated as a multiplier of the VTT such that $VTTR = VTT \cdot \gamma_{VTTR}$. By default, this assumption implied that variations in the VTT also influence the VTTR. This multiplicative treatment of interaction effects was consistent with the UK passenger VTT study and significantly reduced the potential combinations of parameters to be estimated when looking at combinations of traditional additive interaction variables (Hess et al. 2017). Details on the functional form are included in Appendix A.4.

Any further variations in the VTT and VTTR were treated as unobserved heterogeneity. Consistent with the 2014/15 UK passenger VTT study this was implemented by treating θ as a random parameter which is allowed to vary across respondents but not across choice tasks. Estimating random parameter, or mixed logit, models are common practice in the choice modelling and VTT literature (e.g. Train 2009). The choice of the mixing density in this study was between the lognormal and loguniform density to ensure that the VTT would remain positive by default and was based on empirical model fit. The loguniform density had the advantage over the lognormal density that it did not suffer from a very long tail of the VTT distribution as its counterpart (Hess et al. 2017). The mixed logit models made use of 1,000 Halton draws (Train et al. 2009) to simulate the likelihood function, which was sufficient due to the inclusion of a single random variable.

5.5 VTT and VTTR estimates

This section presents the results from the joint analysis of the SP1 and SP2 choice data. The analysis is primarily focused on the OGV sample. The reason for this is that during preliminary analyses the LGV sample was displaying very high VTT values (see Appendix A.3). Separate models were estimated for shippers and carriers on the OGV sample. Within these models heterogeneity in the VTT and VTTR across responding firms was picked up by observed (explanatory variables) and unobserved (randomness in the VTT) heterogeneity as explained above. After the presentation of the modelling results for the OGV sample the same model structure was estimated on the LGV sample.

5.5.1 Selecting the functional form, the treatment of error terms and mixing density

The first step of the modelling process determined the appropriate functional form for the choice model. This included contrasting the RUM, RV and relative models using alternative specifications of the error term and mixing density. The selected specification did not include variables beyond an alternative specific constant, the VTT, the multiplier to obtain the VTTR, the scale parameter μ, the relative scale parameter for SP2, and multipliers for the VTT with respect to trips to port and a distinction between OGV1 and OGV2 vehicles. The parameters estimated in these models were therefore similar to those applied to determine the impact of the exclusion criterion on the VTT in Section 5.1.

The primary selection criterion for determining the best model specification was model fit. Table 28 presents the log-likelihood values for the different model specifications across shippers and carriers. It was consistently observed that i) RV models provide a better fit relative to RUM models, ii) multiplicative error terms improve the log-likelihood compared to additive error terms, iii) mixed logit models further improve the log-likelihood compared to standard multinomial logit (MNL) models, and iv) the lognormal density provides a better fit than the log-uniform distribution.

Table 28: Log-likelihood values for the different model specifications: RUM vs RV

	LL (Shippers)	LL (Carriers)
RUM additive multinomial logit	-1095.38	-2446.57
RUM additive lognormal	-979.44	-2411.33
RUM additive loguniform	-983.95	-2425.76
RUM multiplicative multinomial logit	-958.58	-2368.89
RUM multiplicative lognormal	-912.17	-2283.64
RUM multiplicative loguniform	-914.2	-2288.09
RV additive multinomial logit	-1016.41	-2414.6
RV additive lognormal	-969.37	-2385.49
RV additive loguniform	-973.84	-2397.4
RV multiplicative multinomial logit	-936.46	-2331.15
RV multiplicative lognormal	-897.84	-2281.86
RV multiplicative loguniform	-899.19	-2284.71

Besides contrasting the model fit, the impact of the different model specifications on the VTT and VTTR was also studied. When contrasting the VTT and VTTR emerging under the traditional RUM additive against the RV multiplicative models, they were of the same order of magnitude. When introducing mixed logit models, an increase in the mean VTT and VTTR was observed. This is a common phenomenon as the long tail of the lognormal density does tend to increase the mean of the VTT. For carriers these increases in the mean VTT are acceptable. For shippers, however, the mean VTT increased substantially. There are two potential explanations for this to happen. First, the sample size for shippers was relatively small compared to the carriers (130 vs 257). Second, Table 23 and Table 24 revealed that shippers tended to select the fast and expensive alternative more often and were more likely to accept the highest BVTT values. This response pattern drove up the VTT since the models were unable to put an upper limit on the VTT for the respondents always selecting the fast and expensive option. The recommended approach following from this exercise was the adoption of RV models, with multiplicative error terms, and only to implement mixed logit densities for carriers to circumvent obtaining very high VTT estimates for shippers.

The next comparison was between RV model and relative models. Table 29 compares the relevant model specifications in terms of model fit. Here, conflicting results were obtained for shippers and carriers. For shippers the results indicated adopting the RV specification with multiplicative error terms, whereas for carriers, relative models with multiplicative error terms outperformed the RV models with multiplicative error terms.

Table 29: Comparison of random valuation and relative models in terms of model fit

	Log-likelihood (RV)	Log-likelihood (Relative models)
Shippers – multiplicative error (MNL)	-936.46	-963.7
Carriers – multiplicative error (lognormal)	-2281.86	-2258.93

This outcome was somewhat inconvenient since, in appraisal, applying the VTT from shippers and carriers becomes more complicated when they are based on different premises. For example, this would require different assumptions on updating these values over time. A closer examination of the resulting trade-off ratio of 1.65 within the relative models suggested that transport time was considered too important relative to transport costs resulting in much higher VTT values compared to the RV approach. To illustrate this, the below table describes the emerging VTT for carriers under the relative models. For OGV2 trips, these values were 80-100% higher than their RV counterparts.

Table 30: Illustration of VTT values emerging from the relative models (£2022 prices)

Carriers	Hourly rate based on the 2020 Motor Transport Cost Tables (2022 prices)	Converted into VTT
OGV1 – Not to Port	£65.38	£107.88
OGV1 – To Port	£65.38	£107.88
OGV2 – Not to Port	£92.50	£149.33
OGV2 – To Port	£92.50	£149.33

Source: Motor Transport (2020)

In light of these considerations the recommended approach was to adopt the RV model specification with multiplicative error terms for both shippers and carriers. Additionally, for carriers mixed logit models were estimated using a lognormal density.

5.5.2 Observed heterogeneity in the VTT and VTTR and recommended values per subsample

In this section the results for the OGV models for shippers and carriers are presented before continuing with the results for the LGV shippers and carriers. Two model specifications for each OGV subsample are presented. The first model specification included a wide range of control variables and the second specification retained only the significant variables and removes control variables which display counterintuitive results.

Table 31 displays the full model results for OGV shippers. The alternative specific constant, which only applied to SP2 due to the use of RUM multiplicative models here, shows that after accounting for all factors respondents have a higher tendency to select scenario B over scenario A. The parameter estimate for the VTT, relating here to SP1, not to port, OGV1 shipments can be multiplied by 60 to obtain the central estimate for the VTT, at a value of 0.964 this would come out around £56.76. per hour The corresponding VTTR multiplier of 0.093 indicates that the VTTR for SP1 comes out at £5.28, i.e. just under 10% of the VTT value for the baseline category. However, since reliability was only included in SP2 it also needs to be multiplied with the SP2 multiplier of 2.209, resulting in a VTTR of £11.88. The fact that the VTT in SP2 is higher than in SP1 is consistent with the findings of the 2014/15 UK passenger VTT study in which difference of the same order of magnitude were found (Hess et al 2017). Consistent with that study, the reported VTT was based on the results for SP1 and the reported VTTR was based on the results for SP2.

The next set of parameters describes the degree of scale heterogeneity. To ensure positivity of the μ parameter, it was estimated in exponential form such that $\mu = \exp(0.12) = 1.128$. Two forms of scale heterogeneity were accounted for. First, λ_{SP2} shows that SP2 has a *lower* scale parameter than SP1, i.e. it was associated with more variance. Additionally, this parameter accounted for the conversion of the notion of utility in SP2 to valuation in the RV framework adopted in SP1. Especially this second effect explains the size of the respective parameter. Second, the scale parameter accounts for the fact that many respondents indicated that they found the journey descriptions unclear, which could have resulted in more random responses in the SP. As the results indicate, the corresponding parameter estimate was not significantly different from 1, and thus this did not have an impact on the choice behaviour of the respondents.

In addition to controlling for differences in the VTT between SP1 and SP2, which reveal that SP2 VTT values are a factor 2.209 higher than SP1 factors, the model controls for the impact of characteristics of the 'typical transport' on the VTT using the respective multipliers[7]. Most of these multipliers indicate there are no significant differences from the baseline VTT estimate. As presented, high value goods had a significantly lower VTT. Finally, the distance, time and cost elasticities indicated that only distance was a relevant factor and that the VTT decreased in distance (which is in contrast with the UK's passenger VTT findings where a positive effect was observed).

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[7] That is, the vehicle type, destination of the shipment, value of the good, whether the trip is part of a larger chain, which type of goods are transported, whether these need to be delivered within a specific time window and whether specific fees are associated with late deliveries, the frequency of the delivery (at least once a week), and the packaging of the goods.

Table 31: Full model specification for OGV shippers (RV multiplicative MNL)

	Estimate	Robust standard error
Alternative Specific Constant in SP2 (left)	-4.312	2.249*
VTT and VTTR parameters		
Baseline VTT estimate (θ) per minute	0.964	* 0.577
VTTR multiplier+	0.093	0.061
Scale parameters		
μ_{ln} – log of the scale parameter	0.120	0.107
λ_{SP2}- SP2 scale parameter+	12.971	*** 1.773
$\lambda_{unclear}$- scale parameter for D14+	0.940	0.127
Multipliers on the VTT and VTTR+		
SP2	2.209	0.822
To Port	1.459	0.664
OGV2	1.029	0.279
Low Value goods	0.876	0.274
High Value goods	0.585	** 0.173
No Chain	0.920	0.456
Need to deliver in time	0.863	0.219
Retail goods	1.238	0.380
Perishable goods	0.627	0.227
Manufactured goods	1.032	0.286
Automotive goods	1.414	0.538
Fee for late delivery	0.582	1.491
Weekly deliveries	1.171	0.327
Containers	1.767	0.527
Temperature controlled	1.583	0.615
Boxes	1.200	0.396
Bulk	1.018	0.293
Elasticities		
Distance elasticity	-1.053	**0.520
Time elasticity	0.361	0.660
Cost elasticity	0.672	0.668
LL	-915.08	

+ significant relative to 1 (0 otherwise)
* (**)[***] significant at the 10% (5%) [1%] level

Many of the above effects may be the result of correlation across explanatory variables included in the model. For example, when removing time and cost elasticities from the model, the impact of distance became insignificant, and the elasticity was subsequently removed from the specification. By gradually removing insignificant variables, studying the stability of the parameter estimates, and normalising multipliers associated with counterintuitive results a final model specification was obtained.

Table 32 reveals the final model specification for OGV shippers. The only remaining explanatory variables were the multipliers for SP2 and trips to port. All other interactions with the types of goods and packaging were insignificant, after controlling for whether late delivery only has an impact on the VTTR. Moreover, the multiplier for OGV2 was normalised to 1, because after removing several insignificant control variables the OGV2 multiplier became smaller than 1. The latter is a counterintuitive result, because the expectation is that, all things being equal, VTT OGV2 > VTT OGV1 due to the former vehicle type being associated with higher vehicle and driver costs. OGV2 shippers can therefore be expected to have a higher incentive to reduce transport time on OGV2 vehicles from a cost savings perspective relative to OGV1 vehicles. A statistical reason for OGV1 coming out higher than OGV2 vehicles is that OGV1 shippers have a higher tendency to select the fast and expensive alternative in the SP1 exercises relative to the OGV2 shippers. It was decided to maintain the multiplier for trips to port despite not being significant as this was a specific objective of the study.

Table 32: Final model specification for OGV shippers

	Estimate	Robust standard error
Alternative Specific Constant in SP2 (left)	-3.396	**1.670
VTT and VTTR parameters		
Baseline VTT estimate (θ) per minute	1.203	***0.193
VTTR multiplier+	0.091	***0.058
Scale parameters		
μ_{ln} – log of the scale parameter	0.139	0.101
λ_{SP2}- SP2 scale parameter+	13.196	***1.745
$\lambda_{unclear}$- scale parameter for D14+	0.906	0.128
Multipliers on the VTT and VTTR+		
SP2	1.965	*0.572
To Port	1.314	0.291
LL	-931.2	

+ significant relative to 1 (0 otherwise)
* (**)[***] significant at the 10% (5%) [1%] level

Based on Table 32, a set of recommended VTT and VTTR estimates for OGV shippers is presented in Table 33. Their size and magnitude are discussed in more detail in Section 6.

Table 33: Recommended VTT and VTTR values for OGV shippers

	VTT (SP1 - based) (£2022 prices)	VTTR (SP2 – based) (£2022 prices)
Not to port	£72.21	£12.96
To port	£94.87	£17.02

Table 34 presents the full modelling results for the 257 OGV carriers. The patterns were the same as for the OGV shippers. In SP2 there was a tendency, all other things being equal, to select Scenario B over Scenario A. The VTT in SP2 was significantly higher than in SP1, but again the order of magnitude was consistent with earlier studies. The VTT for OGV2 was again lower than for OGV1 and was normalised in the model refinement stage. Furthermore significant impacts of shipping manufactured goods, the use of weekly deliveries and temperature-controlled vehicles on the VTT were found. Since temperature-controlled vehicles are associated with higher running costs, the multiplier larger than 1 would be expected. In this case, a negative time elasticity was identified, which like the negative distance elasticity found for shippers, was counterintuitive.

Since a mixed logit model was estimated, the mean VTT for the sample could be obtained by using the mean of the lognormal density, such that $\overline{VTT} = 60 \cdot \exp\left(-0.034 + \frac{0.532^2}{2}\right) = £66.79$ per hour. Again, this VTT estimate related to the baseline VTT for SP1, not to port, OGV1, etc. The associate VTTR for SP2 then was £38.83 per hour.

We continued by gradually reducing the number of control variables by removing insignificant variables, studying the stability of the parameter estimates, and normalising multipliers associated with counterintuitive results. Like the results for OGV shippers, when removing the distance and cost elasticities from the model the impact of time became insignificant and the elasticity was subsequently removed from the final specification.

Table 34: Full model results for OGV carriers.

	Estimate	Robust standard error
Alternative Specific Constant in SP2 (left)	-5.393	***1.237
VTT and VTTR parameters		
Baseline VTT estimate (θ) per minute – mean	-0.034	0.238
Baseline VTT estimate (θ) per minute – sigma	0.532	***0.054
VTTR multiplier+	0.200	***0.049
Scale parameters		
μ_{ln} – log of the scale parameter	0.414	***0.069
λ_{SP2}- SP2 scale parameter+	7.944	***0.743
$\lambda_{unclear}$- scale parameter for D14+	1.077	0.096
Multipliers on the VTT and VTTR+		
SP2	2.901	***0.410
To Port	0.996	0.190
OGV2	0.766	***0.093
Low value goods	0.962	0.112
High value goods	1.182	0.197
No chain	0.981	0.181
Need to deliver in time	0.832	*0.101
Retail goods	1.034	0.141
Mail and parcels	1.087	0.169
General haulage	1.266	0.209
Manufactured goods	1.394	***0.151
Fee for late delivery	1.148	0.199
Weekly deliveries	0.802	**0.099
Containers	1.052	0.143
Temperature controlled	1.641	*0.336
Boxes	1.104	0.125
Bulk	1.105	0.151
Elasticities		
Distance elasticity	-0.007	0.248
Time elasticity	-0.501	*0.259
Cost elasticity	0.376	0.263
LL	-2201.84	

+ significant relative to 1 (0 otherwise)
* (**)[***] significant at the 10% (5%) [1%] level

Table 35 presents the final model specification for OGV carriers, where only the SP2 multipliers remained in the final model specification. The majority of multipliers were removed due to being insignificant. Three variables remained significant. First, the VTT for OGV2 was lower than for OGV1, but due to the counterintuitive result (similar to the shippers sample) this multiplier was normalised to 1 imposing the VTT for OGV1 and OGV2 to be the same (refer to Table 23 and Table 24 where OGV1 carriers were more likely to select the fast and expensive alternative and accept higher ranked BVTT bids in SP1). Second, the multiplier for manufactured goods was larger than one and significant. A valid reason why carriers, in terms of running costs, would be affected by the type of good they are requested to transport, could not be identified, and accordingly, this variable was normalised to 1. Third, the multiplier for temperature controlled remained significant at a multiplier level, around 1.65. Despite having a credible explanation why this multiplier would be larger than 1, a multiplier of 1.65 was considered too high to justify the emerging VTT values.

Table 35: Final model specification for OGV carriers

	Estimate	Robust standard error
Alternative Specific Constant in SP2 (left)	-4.996	***1.131
VTT and VTTR parameters		
Baseline VTT estimate (θ) per minute – mean	0.113	**0.052
Baseline VTT estimate (θ) per minute – sigma	0.616	***0.062
VTTR multiplier*	0.205	***0.049
Scale parameters		
μ_{ln} – log of the scale parameter	0.445	***0.067
λ_{SP2}- SP2 scale parameter*	7.807	***0.726
$\lambda_{unclear}$- scale parameter for D14*	1.061	0.094
Multipliers on the VTT and VTTR*		
SP2	2.802	***0.396
LL	-2224.92	

+ significant relative to 1 (0 otherwise)
* (**)[***] significant at the 10% (5%) [1%] level

A single VTT and VTTR estimate therefore emerged (since no credible variations in the VTT across explanatory variables for OGV carriers could be identified). Table 36 reports the recommended VTT and VTTR estimates for OGV carriers.

Table 36: Recommended VTT and VTTR values for OGV carriers

	VTT (SP1 - based) (£2022 prices)	VTTR (SP2 – based) (£2022 prices)
All shipments	£ 81.24	£ 46.77

Having completed the analysis for OGV, the LGV samples for shippers and carriers were revisited. The final model specifications for OGV shippers and carriers were re-estimated on the LGV samples, making adjustments were necessary. A key difference between the LGV carriers and OGV carriers' model was that the mixed logit component was removed to account for the smaller LGV samples size. Table 37 presents the final model for the LGV carriers. A similar set of recommend VTT values for LGV carriers is presented in Table 38.

Table 37: Final model for LGV carriers

	Estimate	Robust standard error
Alternative Specific Constant in SP2 (left)	0.142	0.939
VTT and VTTR parameters		
Baseline VTT estimate (θ) per minute	1.064	***0.166
VTTR multiplier+	0.478	***0.121
Scale parameters		
μ_{ln} – log of the scale parameter	0.428	**0.189
λ_{SP2}- SP2 scale parameter+	12.738	***3.915
$\lambda_{unclear}$- scale parameter for D14+	0.994	***0.190
Multipliers on the VTT and VTTR+		
SP2	1.466	0.915
LL	-325.05	
+ significant relative to 1 (0 otherwise) * (**)[***] significant at the 10% (5%) [1%] level		

As expected, LGV carriers had a lower VTT than their OGV counterparts, but their VTTR estimates were largely comparable.

Table 38: Recommended VTT and VTTR values for LGV carriers

	VTT (SP1 - based) (£2022 prices)	VTTR (SP2 – based) (£2022 prices)
All shipments	£ 63.83	£ 44.75

The LGV shippers sample was more problematic, and the assumptions in relation to exclusion criterion C5 were largely influential. Since LGV shippers were consistently accepting high BVTT bids in SP1, the corresponding VTT was much larger than for the OGV estimates. Appendix A.3 includes detail on making the exclusion criterion much stricter, and thereby reducing the sample size decreases to an acceptable proportions, such decisions were too arbitrary and insufficiently robust. The displayed choice behaviour by the LGV shippers together with the small sample size led to the decision not to base the corresponding VTT estimates based on the analysis for this subsample. Instead, the recommendation was to apply the OGV shipper VTT and VTTR estimates to the LGV shippers cohort.

For completeness Table 39 summarises the recommended VTT and VTTR estimates across the different subsamples, including their standard errors.

Table 39: Summary of recommended VTT and VTTR values per hour including standard errors

	VTT		VTTR	
Shippers – OGV and LGV	Value (£2022 prices)	Standard error	Value (£2022 prices)	Standard error
Not to Port	£ 72.21	11.61	£ 12.96	7.97
To Port	£ 94.87	14.93	£ 17.02	11.13
Carriers - OGV	£ 81.24	5.78	£ 46.77	10.87
Carriers - LGV	£ 63.83	9.93	£ 44.75	22.77

5.6 Conversion for use in TAG appraisal

5.6.1 Implications for appraisal

Where Section 5.5 produced VTT and VTTR estimates for different segments, this section focuses on how these estimates can be used for appraisal purposes. The extent to which the detailed values can be used really depends on the level of detail used in the freight transport models with which the values would be combined.

These freight models were typically not able to distinguish between shippers and carriers but were able to differentiate between loaded and empty trucks, the type of vehicle used (LGV or OGV), and possibly the destination of the trip (Not to port vs to port). Recommended values for the latter two categories are presented in Table 39 but loaded and empty transports are not shown. The SP experiments addressed this with carriers only considering transport costs and shippers (that contract out) only considering cargo costs. Therefore, empty transports were the carrier transport costs, and loaded transports were the combination of carrier transport costs and shipper cargo costs. Table 40 shows the specific VTT and VTTR values associated with this level of segmentation.

Table 40: VTT, VTTR, and reliability ratios for specific shipments

		VTT (£/hour 2022 prices)		VTTR (£/hour 2022 prices)		Reliability ratio	
		LGV	OGV	LGV	OGV	LGV	OGV
Loaded	**To port**	£ 158.70	£ 176.11	£ 61.77	£ 63.79	0.39	0.36
	Not to port	£ 136.04	£ 153.45	£ 57.71	£ 59.73	0.42	0.39
Empty	**To port**	£ 63.83	£ 81.24	£ 44.75	£ 46.77	0.70	0.58
	Not to port	£ 63.83	£ 81.24	£ 44.75	£ 46.77	0.70	0.58

When the freight models were not able to distinguish between the above categories, we needed to take a weighted average to arrive at a recommended VTT and VTTR value. The weights we used in this study for OGV were based on the Continuing Survey of Road Goods Transport (CSRGT) for which the main results are published by the DfTs Road Freight Statistics (DfT, 2023a). For the purposes of this report, the ungrossed CSRGT data were used to identify the four relevant segments (loaded/empty vs (not) to port) and the weights for averaging were obtained by using the grossing weights in CSRGT as expansion factors to get their representative shares. Information for LGV vehicles was not included in the CSRGT database. The DfT Road Stats table TRA0201 (DfT, 2022a) has national vehicle km for LGVs and HGVs; it is a 76:24 ratio for 2021, which combined with the 88:12 LGV freight: non-freight ratio in Tab A1.3.4 of the TAG Data Book resulted in a 27:73 overall ratio of LGV freight to HGV freight. Furthermore, the 19/20 Van Statistics VAN0309 (DfT, 2021) recorded that LGVs used for delivery/collection of goods purposes had on average 18 stops a day, which results in adopting a 18/19 loaded vs 1/19 empty split. The trips to port were scaled using the OGV representation of 4% of trips going to port.

Table 41: Weights used to generate representative VTT and VTTR values

		LGV	OGV	Total
Loaded	**To port**	1.02%	2.72%	4%
	Not to port	24.56%	47.60%	72%
Empty	**To port**	0.06%	0.00%	0%
	Not to port	1.36%	22.68%	24%
Total		**27%**	**73%**	**100%**

Combining the information from Table 40 and Table 41 provided the following representative VTT and VTTR values to be used in appraisal. In Table 42 it was assumed that the freight model i) was not able to distinguish between any of the variations, and ii) was able to distinguish only with respect to the vehicle type used. Additional combinations could be made based on the above tables and using the relevant weights.

When used in appraisal, to avoid double-counting, these values should be recognised as including non-fuel time-dependent transport costs. The table below thus would replace Table A1.3.1 driver-related time values, and the time-related part of Table A1.3.14 (the non-fuel vehicle operating costs).

Table 42: Representative VTT and VTTR values using hypothetical weighted averages

	VTT (£/hour 2022 prices)	VTTR (£/hour 2022 prices)	Reliability ratio (at average)
Average	£ 132.19	£ 56.21	0.43
Average LGV	£ 133.10	£ 57.18	0.43
Average OGV	£ 131.86	£ 55.85	0.42

5.6.2 Treatment in the current TAG

Freight VTT

The current treatment of freight time benefits and gains in non-fuel vehicle operating costs is explained in TAG unit A1.3 (DfT, 2022b) and the equations and values used can be found in the TAG Data Book v1.20.2 (DfT 2023b), Tables A1.3.1 and A1.3.14.

The time benefits for freight in TAG (DfT, 2023b) currently only include the time of the driver (or passenger), with a differentiation between LGV[8] and a single category of OGV (Table A1.3.1). The VTT of the carriers that was found in this study includes other time-dependent transport costs, including the costs related to the vehicle (this corresponds to the time-related depreciation and vehicle capital saving 'b1' parameter in TAG A1.3). The elements of transport costs that are not included in the new carrier VTT are the fuel costs and other purely distance-related costs (toll cost, tyres, oil, mileage and maintenance related depreciation: 'a1' in TAG A1.3). In the current TAG, these are included in the vehicle operating cost (VOC)

[8] Note that the LGVs in TAG are not just those used in freight transport, they include service vehicles as well. Our values for LGV VTT only refer to the LGVs used in freight transport (including the possibility of empty returns). To be able to use these specific freight van VTTs, the analyst needs to distinguish between use of vans for freight transport, and of service vehicles in project appraisal.

gains. The VOC in TAG includes the fuel component alongside oil, tyres, vehicle maintenance cost, depreciation and capital tied up in the vehicles. This non-fuel component consists of a distance-related and a time-related part (Table A1.3.14). When using the VTT from our study, this replaces the Table A1.3.1 driver-related time values, and the time-related part of the non-fuel VOC (Table A1.3.14). TAG for this component distinguishes between LGV (for freight transport, these will always be vehicles in working time), OGV1 and OGV2.

If a project would change the travel times for freight transport, the VTT from our study includes all time-related costs plus the cargo component. The cargo component is currently not treated in TAG, so does not replace a current value. The fuel cost component of the VOC and the distance-related part of the non-fuel VOC should remain in use (just as they are used in appraisal at present) when the new VTTs from this study are applied.

According to TAG unit A1.3, the VTT (drivers) for other years is determined by using the growth of real GDP per capita with an elasticity of 1 (or just 1.5% per annum). The non-fuel VOC would remain constant over time in real terms (as defined by the GDP deflator), whereas the VOC (because of the fuel component) in total would depend on aspects such as fleet mix and fuel price growth.

Comparison with current TAG values

With the aim of making the current TAG values comparable with the results from this study, we can compare the VTT associated with the transport costs, as reported in Table 40 by empty transports at £63.83 and £81.24 for LGV and OGV respectively, with the current TAG values. Converting this study's 2022 values into 2010 prices using GDP deflation result in VTTs of £44.54 and £56.68 for LGV and OGV expressed in 2010 prices. The TAG values for the driver's time were respectively £10.52 (LGV) and £12.13 (OGV) per hour in 2010 prices (DfT, 2023b). Adding to this the time-based VOC (non-fuel) from TAG Table A.1.3.14 at £0.47 (LGV), £2.63 (OGV1), and £5.09 (OGV2) results in VTTs of £10.99 (LGV) and £16.26 (OGV) based on TAG in 2010.

Table 43: VTT comparison with current TAG values (DfT, 2023b)

		This study, 2022 prices	This study, 2010 prices, 2010 GDP	TAG, driver and non-fuel costs (2010 prices)
Empty	**LGV**	£ 63.83	£ 44.54	£ 10.99
	OGV	£ 81.24	£ 56.68	£ 16.26

To average the time-based VOC (non-fuel) costs across OGV1 and OGV2, shares of 39% and 61% were used to arrive at an average cost of £4.13 per hour, where the shares were based on relative vehicle registrations by category obtained from CSRGT data from July 2021 to June 2022. Altogether, the VTT values obtained by this study are a factor 4.1 higher for LGV (£44.54/£10.99) and 3.5 for OGV (£56.68/£16.26). Perspectives on this observed difference are provided in Section 6 below.

Freight VTTR

For different types of roads, TAG unit A1.3 uses different values of reliability, and different metrics. For urban road, the standard deviation-based reliability ratio is used, and the value of 0.4 is recommended for car. For interurban strategic roads a standard practice reliability ratio of 0.6 is used for OGVs in the MyRIAD (National Highways) software, although this is not stated in TAG.

5.6.3 Possible distinctions on the basis of the new values

Freight VTT

In this study, the shippers (cargo related) VTT is added to the carriers (staff and vehicle time cost related) VTT to obtain the overall VTT of a loaded vehicle. For empty vehicles the carrier VTT only applies because transport costs are still relevant yet there is no cargo component. This implies that we do not provide separate carrier and shipper values for appraisal, but researchers doing appraisals in practice are supplied with different values for loaded and empty road freight transport vehicles. In case researchers cannot make the distinction in their forecasts between loaded and empty vehicles, we calculated a weighted average value, with national weights derived from CSRGT, that applies to vehicles, irrespective of whether they are loaded or empty.

Likewise, we provide separate values for LGV and OGV (a distinction between OGV1 and OGV2 as now made for VOC is not possible on the basis of the estimated models). A researcher doing appraisals can use these differentiated values, but in case the forecasting model does not allow this distinction by vehicle type, a weighted average for all vehicle types used in road freight transport is provided, as derived using CSRGT.

Finally for transport going to ports, airports, train cargo terminals, and the Channel Tunnel we have a different VTT than for all other transports (including transport having the locations mentioned as their origin). A researcher can use the different values for both groups if they have the required forecasts, but in case they cannot make this differentiation in the forecasts, they can use the weighted average, as derived using CSRGT.

Our recommendation for the growth over time of the VTT is to use the price index numbers for the staff and vehicle time-related transport cost components, and (if possible) specific indices for road freight transport cost such as the wages (otherwise the CPI, so that that remain constant in real terms or GDP as that is TAG's definition of real). For the change in the cargo component, we suggest the real GDP growth, since the goods values are likely to rise closely to GDP growth.

In this respect, is notable that when the surveys took place in 2022 was an all-time-high for the transport costs. By April 2023, fuel costs, and possibly other cost components, were lower than at the time of the survey, so the 2023 VTT may be below the 2022 VTT that was found, and would be a better starting point (see subsequent section).

Freight VTTR

For the freight VTTR, the same notes apply as for the freight VTT. And likewise, weighted average VTTRs are provided, on the basis of weights from CSRGT.

6. Assurance

6.1 Survey assurance

6.1.1 Fieldwork timing

In order to obtain representative survey results spring/ early summer was chosen as the target survey period. The decision was made to avoid the first quarter, which is always the quietest and often suffers from bad weather conditions affecting the roads. The fourth quarter is usually busy on the run up to Christmas and hence engagement with stakeholders tends to be difficult.

Survey responses dropped off in July before the target number had been reached. The experience of the pilot survey showed that the month of August was particularly difficult to generate participation with respondents due to people being on annual leave and a secondary effect of additional pressures on the remaining workforce. As a result, a soft break was taken for five weeks from the end of July until the beginning of September to re-focus resources, and to encourage participation. No new calls were made during this period, and the interviewing team was scaled back to only deal with calls and communication with businesses who already had the link or that were trying to complete the survey.

Fieldwork restarted in September 2022 by which stage it was clear that some subsamples were further off from being completed than others (the survey needed more shippers and more ‘to port’ journeys than the responses from the respondents were indicating at the time). Contact with businesses was therefore targeted to meet quotas for each of the subsamples.

A secondary platform of the survey was also created. This facilitated targeted communication for shippers in the sample and towards them providing a ‘to port’ journey for their completed survey. This meant the study team had a two-tiered platform in SNAP survey software, one targeting completed surveys and another one which was targeting shippers in particular. This improved the performance of the survey to include a more balanced sample across the subsamples. Table 12 shows the number of responses for each subsample following data cleaning.

6.1.2 The high costs of freight at the time of the survey

The spring/summer of 2022 saw influence from the on-going disruption caused by Covid-19 and Brexit, alongside the war in Ukraine, and its impact on fuel costs and wider inflation.

A review of haulage costs and pricing in the period before and since the survey has shown some notable trends. Costs and prices were rising steadily through 2021 and the rises became very sharp through the first half of 2022 to an all-time peak in most indicators in the third quarter of 2022, when the surveys were conducted. Costs of new and secondhand vehicles, parts, fuel and other energy costs were all rising at the same time contributing to high levels of inflation. The driver shortage and rising inflation reportedly prompted double digit pay settlements with drivers in order to retain them in the sector.

As transport is a service sector operating across the world it is useful to review not just UK costs but those from further afield and especially European road hauliers as they operate to and within the UK. The European Road Freight Price Index tracks the trajectory of average European road freight rates every quarter. Figure 5 shows that spot rates reached their peak in quarter 3 of 2022, following a significant rise since Quarter 2 of 2020. Spot rates declined by 2.4 points between quarter 3 and quarter 4 of 2022, but remained very high (Upply, 2023). Historically, Q1 of each year tends to be the quietest quarter for the industry.

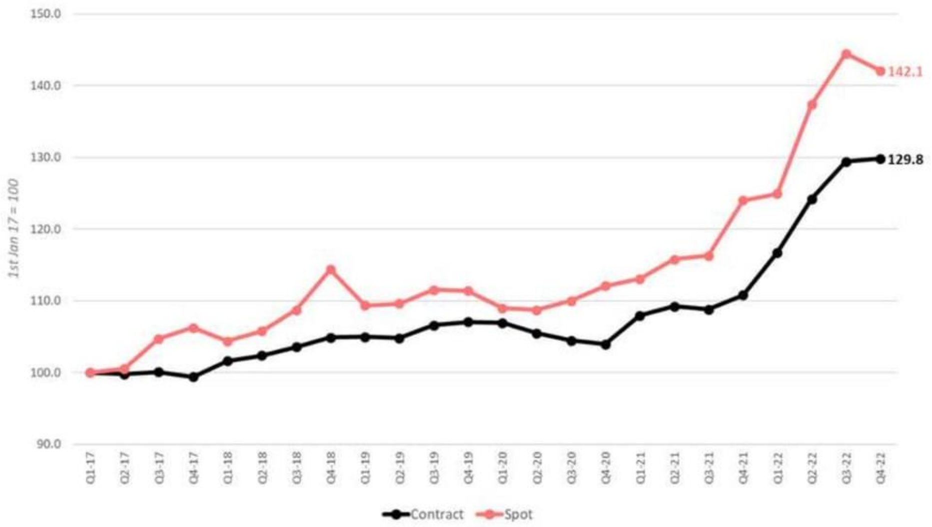

Figure 5: Ti x Upply x IRU European road freight benchmark European road freight rates index, Q4-2022 (Upply, 2023)

The drop in rates is expected to continue in 2023, although perhaps not so steeply. There are several reasons for this, including:

- High inflationary rates – This increased key costs for transport operators, including vehicle and maintenance costs. Inflation has also negatively impacted consumer and business demand and, consequently, on transport needs, especially since stock levels were already very high (Ibid).
- High fuel costs – The surge in fuel prices eased in the fourth quarter of 2022, with this trend expected to continue, however these are still higher than they were a year ago. On average, Q4 2022 diesel prices were 21.5% more expensive than January 2022 levels (Ibid and IRU, 2023).
- Continued driver shortage – This has now become a structural part of the industry and is having consequences on the cost of labour. Driver shortages across Europe did actually ease slightly in December 2022, although the number of unfilled positions remained high at between 380,000-425,000, around 10% of all driver positions (Upply, 2022).
- Supply of microchips/semi-conductors – These were been in short supply causing prices to rise, although this is easing as of spring 2023. At the height of the chip shortage, global auto production reduced 26% during the first nine months of 2021. However, in 2023, global vehicle production has been increasing (JP Morgan, 2023). This is shown in Figure 6.

Figure 6: European auto production volumes in 2023 (year-over-year) (JP Morgan, 2023)

Figure 7 shows truck transport prices in Europe, showing that this peaked in the summer of 2022 before falling in early 2023. This has been a relatively sharp decrease, following around 7 months of prices being high at around 1.6 euros/km. The direction of change of the average cost also shows a slight downward trend over the last year (Della, 2023). (note – a tilt trailer is a typical vehicle across Mainland Europe which is similar to curtainsiders in the UK. Typical payload is about 20 tonnes as these vehicles tend to run at 40 tonnes gross)

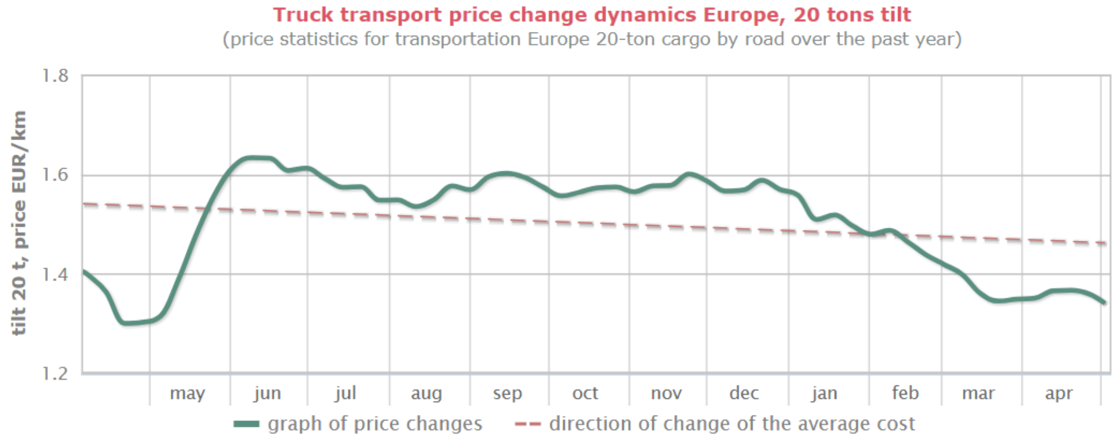

Figure 7: Truck transport price change dynamics Europe (Apr 2022 – Apr 2023) (Della, 2023)

Figure 8 shows that logistics companies have concerns about inflation impacting the industry. On Logistics UK's Logistics Performance Tracker, this dropped the UK economic outlook for the next 6 months from 4.0 in Q1 2022 to 3.5 in Q2 2022 (Logistics UK, 2022).

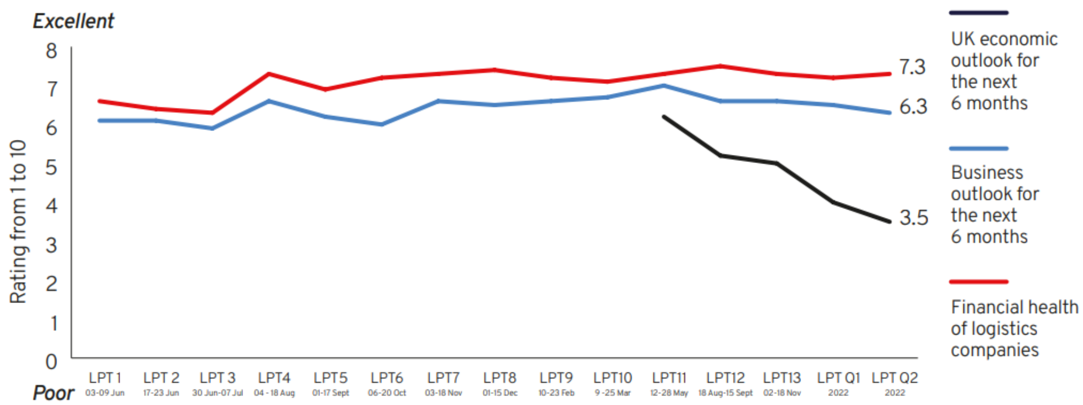

Figure 8: Business and economic outlook, and financial health of logistics companies (Logistics UK, 2022)

The conclusion of this review of data is that costs were at an all-time peak in the third quarter of 2022 and that knowledge of this should be factored in when using information from this report (as suggested in the previous section).

6.1.3 Processing survey data

The data was subject to a systematic data cleaning process and any edits performed on the data were undertaken using SPSS (a software statistics package) syntax commands so changes were recorded and can be audited. Any 'other' answers were added to a pre-coded list or had a separate code added at the coding stage, as appropriate to the comment.

The survey platform undertook the following steps automatically:

- Downloaded all rows of data (including all partial completes where respondents had started the survey but not completed).
- Allocated a respondent ID, a code to identify the location of the respondent and the type of respondent.
- Range checks were applied to all variables at the time of interview. These checks ensured that the data supplied fell within predetermined limits.
- Automatic skip-and-fill routines were applied to ensure that the correct routing had been followed throughout each questionnaire.
- Logic checks were applied at the time of interview to ensure that the answers were sensible and consistent with each other.

Response data was downloaded from the online survey platform (SNAP) and imported into SPSS before being appended with the SP data that had been fed in behind the survey. Data was cleaned to ensure accuracy as follows:

- All questions not answered by a respondent were given the same value as missing data to ensure these were not included in the analysis.
- Where a response was specified in free text which could be attributed to an answer in the list provided in the questionnaire, this was updated.

The frequencies for each response per question were calculated, checked and verified to ensure all data had either a response, a no comment or a missing value. As respondents were not obliged to answer all questions in the questionnaire, the percentages in the frequencies only included those that responded to each question. Where percentages did not sum to 100%, this is due to rounding.

Syntax set up at the pilot stage was amended to account for any changes between pilot and main survey and each dataset produced was seen by and checked by at least two independent members study team staff.

Handover to data processing team

A handover meeting was set up between the survey team and the data processing team[9] to handover the data post-main survey. The data was discussed so that the survey team could identify what they had done, what variables had been created to assist in the analysis and what further support to the data processing team still needed from the survey team regarding the data whilst they conducted their own checks and verifications.

Checks on consistency of responses

The two main steps in preparing the survey data for analysis and model estimation were checking the validity of the data and restructuring the data into a suitable format. The process of the former involved the following set of checks:

- Basic checks on dataset validity (empty cells, data structure).
- Consistency with experimental design.
- Correct presentation of attribute values to the respondent.
- Rudimentary analysis of behavioural choice.

Responses with multiple missing or erroneous data entries were discarded from the dataset. In the survey dataset one data entry (i.e. one respondent) was discarded for missing numerous data values needed for the modelling phase. The second check was a verification on whether the setup of the experiment was followed during the data collection phase. It was verified that for most of the survey, the experimental design was followed. This check uncovered study team errors in swapping of data values between different respondents

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[9] These were three separate members of the study team consortia: AECOM (survey team), and ITS / Significance working together (data processing team).

in a few instances in earlier versions of the dataset. After corrections, a limited number of cases showed swapping of the left and right alternatives compared to the experimental design. This was not deemed a problem as the order of alternatives and order of questions were randomised during the data collection phase; typical for choice experiments to prevent bias. Linked to the previous check is that the attribute values were correctly calculated and presented to the respondent during the survey. It was verified that all attribute values shown to the respondent matched the intended values provided by the experimental design.

Additionally, a basic exploration of choice behaviour was performed, based on the trade-offs presented in the first (SP1) experiment. The SP1 experiment consisted of eight time vs cost choice tasks per respondent. For example, a choice task where alternative A is 10 minutes slower and £1 cheaper compared to alternative B. The presented trade-off (or implicit bid) in this choice task is £6/hour. This implicit bid is also known as the Boundary Value of Travel Time (BVTT) and respondents with a VTT higher than the BVTT were expected to select the fast and expensive alternative B whereas those with a lower VTT are expected to select the slow and cheap alternative A. The SP1 choice tasks were designed in such a way that a wide range of these trade-offs were presented to the same respondent. Subsequently, if one would reject a trade-off of £6/hour (i.e. chose the cheaper/slower option), it would not be intuitive if the respondent elsewhere accepted a £30/hour trade-off.

In checking the consistency of the response patterns in SP1 some errors in the data exportation were detected. Figure 1 depicts for a subset of respondents (vertically), the presented range of BVTT values horizontally and the acceptance /rejection of the trade-off bid (colour-coded). The error in the data export was detected because the presented BVTT values were identical across a large share of respondents, including the observed choices (see the rectangle highlighting this for a set of respondents but the pattern can be observed in multiple instances in Figure 1). The identical BVTT values that were exported are represented by the vertically aligned BVTT values whereas the identical choices are illustrated by the same colour coding across respondents. By design the BVTT values were expected to vary across respondents due to variation in the time and cost of the reference transport around which the presented times and costs are pivoted using relative changes in time and cost to the reference transport.

The observed choices in the exported data were irregular and provided a strong indication of duplicated choice observations in the survey data. Further examination of the dataset confirmed the existence of duplicated entries in 39% of the dataset. Some reference trip time and cost, choice tasks, attribute values and registered choices were duplicated. This insight led to the discovery of inaccurate survey data aggregations, which were amended before the model estimation phase. The new dataset was again checked on the aforementioned points and was found to be valid for the analysis phase.

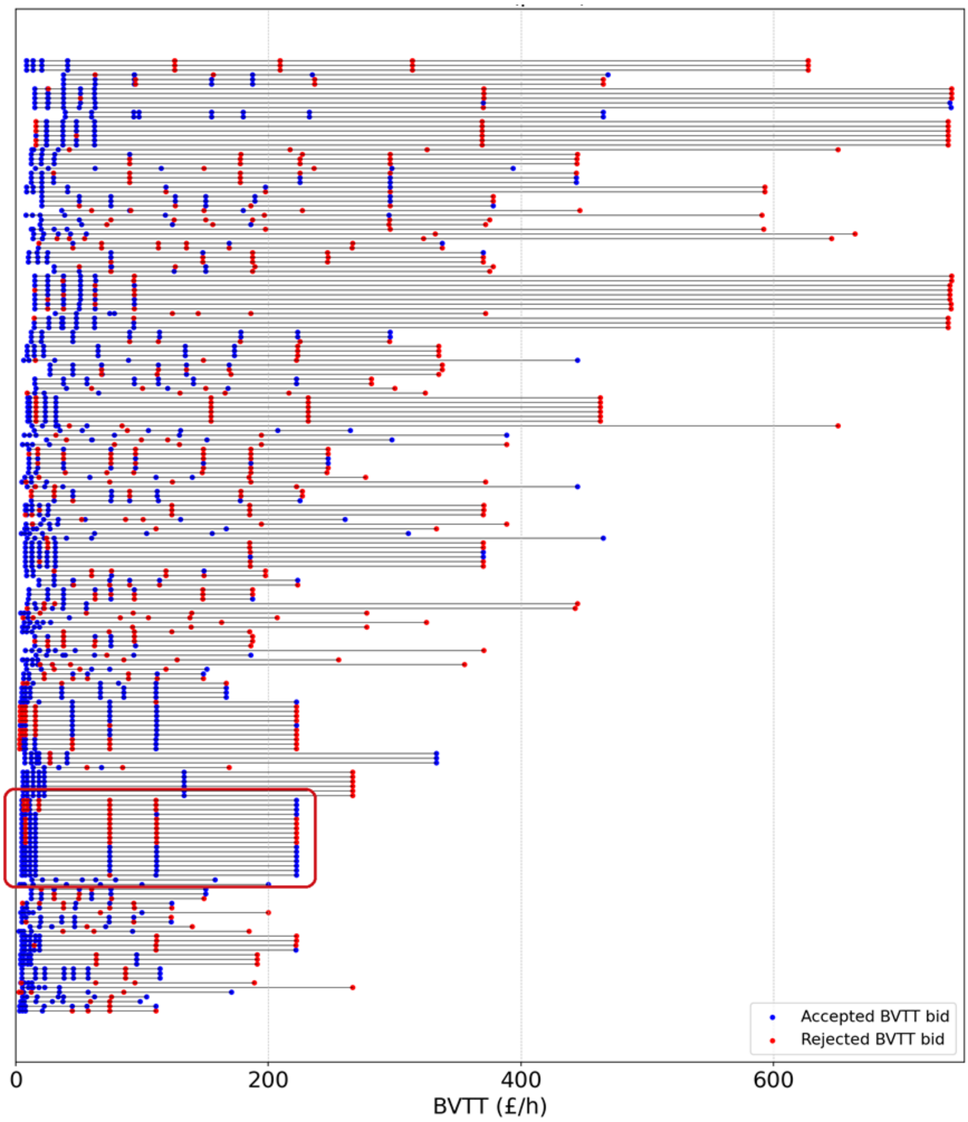

Figure 1 - Implicit bid acceptance/rejection for subset of SP1 respondents

As a result of these checks by the data processing team further checks were conducted on the original raw data. The outcome of those investigations is outlined below.

Checks on survey platform export

At the start of the project programme, it was discussed what survey software programmes could be used for the purpose of this survey SNAP was chosen due to its existing use in the study team. As the questionnaire design was developed, it became clear that the survey itself and the need for complex calculations behind the questionnaire was going to be a challenge, one that superseded previous scripting works on other projects. To that end, the study team worked with SNAP direct to figure out the design requirements throughout the pre-pilot stage in order to create the calculations and variables needed for the SP sections of the questionnaire to work and was rewarded when through that engagement, the study team and SNAP were able to develop the necessary elements needed in order for it to work.

During the second part of the main fieldwork (post-summer break) the study team created a sub-platform on the survey platform to target specific businesses (to allow for a tweak in the targeted messaging, on who we were targeting etc), a method which unfortunately was not used or tested on the platform in the pilot as it was not required.

When exporting the data from the sub-platform, this required a slightly different method (one which has not been used previously) and therefore an export error occurred where duplication was caused and was not spotted when the completed surveys were downloaded. This resulted in a cumulative error being repeated in the download, rather than the correct individual cases being downloaded.

Therefore, after downloading all the cases and removing and cleaning out any partial / abandoned / incomplete cases (see Section 5.1), there were 602 individual unique cases remaining. However, the error in how the cumulative data was downloaded from the sub-platform meant that a number of cases were downloaded twice cumulatively, and some cases also were not downloaded correctly, therefore still providing 602 cases, but not all 602 cases were unique. This was discovered after certain key variables were identified and analysed for different parameters.

This was resolved and re-downloaded correctly, outputting 602 unique cases for analysis.

Checks on SP input data appending

As noted, the survey platform (SNAP) required a number of calculations and feeding in of the scenarios used in the SP design of the survey. This was tested extensively both at the pilot and during the main stages of the survey development by the study team. The correct SP scenarios were fed in at random and the calculations then took their previous responses, added in the chosen SP scenario and displayed their personal scenarios on screen to answer.

When the completed data was downloaded, each completed case needed to have the SP data appended to the final exported data, so that the data processing team would know which SP scenarios each business was presented with when going through the questionnaire. This information was needed to be incorporated into the analysis.

Between the pilot and main survey, there were some design changes made and the syntax used with the completed data also needed to be changed accordingly. However, on a selection of variables, that syntax change was not picked up and therefore it overwrote some of the existing syntax. This produced appended data which was duplicated and not the correct appended data for each case.

The survey team re-visited the original raw data and followed the data checking and verification process from the beginning to identify the two areas raised by the data team. By exporting the raw data and following the process again and being able to audit the specific cases the survey team were able to follow the data case through the process and understand what happened.

Additional members of the consortia, who had not previously been involved with the data, were brought in to audit the data from a checking and verification standpoint as they were independent to the data collection and original data verification process, allowing them to undertake a more forensic analysis of the data to understand how and where things were duplicated.

By following through the cases from the original raw data, the specific lines in the syntax where the errors were occurring were identified by the study team and then an intensive period of re-downloading of the affected cases and the appending of the data took place. The team then undertook a step by step analysis of the whole dataset, following cases through from completion through the download, through the cleaning and appending stages and then checking that the SP scenario data was also coming out correctly.

By following through the steps taken, by process of elimination, the survey team were able to verify where the errors had occurred and rectify them such that the results are legitimate.

6.2 Analysis assurance

6.2.1 Derived freight VTT compared to others

A comparison with current TAG values is given in Section 5.6.2.

Previous European studies

An overview of road freight VTTs in the SP and RP literature is shown in Table 44. Note that these values are not per tonne, but per transport per hour.

Table 44: VTT for freight transport by road (in 2010 euro per transport per hour)

Publication	Country	Data	Method	VTT (2010 € per transport per hour)
The goods component in the VTT:				
De Jong (2008)	Various Scandinavian studies up to 2001	SP	Different discrete choice models	€0-10
Danielis et al. (2005)	Italy	SP	Ordered probit	€7
IRE and RAPP Trans (2005), Maggi and Rudel (2008)	Switzerland	SP	MNL	€14
Fries et al. (2010)	Switzerland	SP	Mixed logit	€4
Halse et al. (2010)	Norway	SP	MNL and mixed logit	Large truck (carrying on average 12 t): €9
De Jong et al. (2011)	Netherlands	RP (mode choice)	Aggregate logit	€6
Johnson and de Jong (2010)	Sweden	RP (mode and shipment size choice)	MNL and mixed logit	€24
Significance et al. (2013)	Netherlands	SP	MNL	€6
Wallis and King (2019)	New Zealand	Open-ended contingent valuation		€4
Halse et al. (2019)	Norway	SP	MNL	€10
Jensen et al. (2019)	Europe (data for Sweden and France)	RP among shippers	Nested logit	€0.10–0.80
De Tremerie (2019)	Belgium	SP	MNL, mixed logit and hybrid choice model	€0.20–0.30
The transport service component in the VTT:				
Halse et al. (2010)	Norway	Cost data	Factor cost	Large truck (carrying on average 12 t): €72
De Jong et al. (2011)	Netherlands	Cost data	Factor cost	€27
Significance et al. (2013)	Netherlands	SP	MNL	€32
Both components in the VTT:				
De Jong (2008)	Various countries	Mostly SP	Mostly MNL	€35-60
Halse et al. (2010)	Norway	Cost data and SP	Factor cost and MNL and mixed logit	Large truck (carrying on average 12 t): €81 Truck (carrying 8 t): €54
Significance et al. (2013)	Netherlands	SP	MNL	€38

These values include the studies on which the freight VTTs for use in transport project appraisal in the Netherlands and Norway are based. Accounting for inflation in the Euro area (Eurostat, 2023), taking into account the real growth in the freight VTT over time by using the rate of real GDP per capita growth over this period, and converting to Sterling (using XE, 2022) gives values of £47 – £109 for 2022, in 2022 prices.

Typically in these studies, 85% of total VTT was attributed to the carrier/time-dependent transport costs and 15% to the cargo. The transport cost component of the VTT in several of these studies was found to correspond well with the full transport cost per hour minus the pure distance-related costs (that is mainly the fuel costs).

Meta-regression study in the United States

Another benchmark is the meta-analysis on the freight VTT (Binsuwadan, 2022). This meta-regression was based on 56 primary studies around the world, but mainly in high income countries. This regression can be applied to the UK, resulting in a freight VTT for road transport for carriers of US $10.24 per tonne per hour and US $1.56 for shippers. If the first value relates to transport costs and the second to cargo (which for several studies is not evident; however, the shares of the transport cost component and the cargo component of 85% and 15% are consistent with the table above), we get a value of US$11.80 per tonne per hour (2017 prices). Taking into account an inflation rate between 2017 and 2022 (World Bank, 2023) and using the growth rate for the freight VTT with real GDP/capita of 1.5% per year we get US$14.70 or £11.70 per hour per tonne for 2022. At 10 tonnes per vehicle this would mean £117 per vehicle, which is higher than the £109 upper limit value from the European studies above.

Comparison with this study

The 2022 values that we found in our study for carriers (LGV £63.83, OGV £81.84, see Table 39) are within the range of values (~27% to ~56% of the £47-109 range, ~25% to ~50% of the £47-117) range (and as such are also in line with values for the transport cost component found in Dutch and Norwegian national freight VTT studies).

Impacts on freight industry costs

The values from this study also correspond reasonably well with the average transport cost per hour, considering that typically around 30% is distance dependent cost, from the UK Motor Transport Cost (2020) tables (£35 for LGV, £65 for OGV1 and £93 for OGV2).

Although, the values that we found on the cargo component (for shippers) were higher than the benchmark 15% of the total VTT found in the above literature and meta-analysis, such that the shipper VTT doubled the overall (shipper + carrier) VTT. Higher values than presented in Table 44 were found in some earlier studies. This shows that VTTs could be higher for specific carriers, and especially for specific shippers. They also show that a value for the cargo component that doubles the transport costs component is perfectly feasible.

The first national freight VTT study in the Netherlands (Hague Consulting Group, 1992) carried out SP experiments for a specific shipment and found values that were in line with those in the international summary shown in Table 44. But this study also included another SP survey, called the strategic stated preference (SSP) survey. The SSP study was intended as a first exploration of the travel time valuation in the long term. The earlier contextual stated preference (CSP) interviews (i.e. experiments for a single typical shipment) included a number of screening questions to identify companies that make strategic decisions (such as different modal split, other locations) and/or are severely affected if structural travel time losses occur. 21 of the 119 companies in the CSP survey (shippers and carriers) were subsequently re-surveyed. Instead of a typical transport, the alternatives related to all transport during rush hour, on motorways and in inner cities (Experiment I), and all transport (Experiment II).

The alternatives were described by the characteristics total annual travel time, total operating costs and average percentage not on time. Both experiments asked about the willingness to pay of the companies in order to prevent structural delays and unreliability.

The results of the SSP study indicated that in the event of large, structural travel time losses, the implied monetary losses in the long term (5-30 years) for the companies could amount to two to three times the CSP value for road traffic. It should be emphasized, however, that this was a subset of companies, namely those where additional losses are most likely.

Research by Mackie and Tweddle (1993) in the UK confirmed the existence of the wider benefits to industry from road improvements as a result of time savings because of changes in distribution and inventory requirements. They estimated the proportion of savings from these improvements to be between 1 and 1.3 times the transport cost savings, depending on the type of industry.

Infrastructure projects often lead to decreases in freight transport time. The direct benefits for goods transport are lower transport costs. The evidence collected in the above-mentioned value of time studies, which were mainly SP surveys, suggests that these benefits are proportional or almost proportional to the decrease in transport time. In exceptional cases there may also be extra benefits related to the decline in the value of goods during transport (perishable goods, long delays) or extra inventory and pilferage costs for goods in transit (very high-valued goods, long delays). These direct benefits are reflected in the nationally recommended values of time. For large and lasting changes in travel time, there may be additional indirect benefits such as the indirect or reorganization benefits of transport time savings consist of opportunities to reorganize the distribution and logistics process; opportunities which are presently lost because of longer and unreliable transport times.

These long-run effects might not be included in the trade-offs that respondents make when comparing within or between-mode alternatives in SP experiments. In a study into the economic cost of barriers to road transport (Hague Consulting Group, 1998) these effects were investigated (interviews with shippers and carriers, literature survey and expert interviews in England, France, Italy, the Czech Republic and Poland). The main conclusion was that the most important lost opportunities of barriers to road transport were related to depot structure and inventory size. The relative magnitude of the indirect cost varied greatly from company to company. For some firms the possibilities to reorganise if the impediments were lifted were small and the total costs of the impediments comprised nearly 100% of transport cost. For other firms, the opportunities to save on inventory cost or to change the depot structure were enormous, and the indirect costs (greatly) exceeded the direct cost.

Producers/traders with their own transport and hauliers/forwarders were asked in the interview to provide estimates of their lost revenue, including missed opportunities, due to the forced inactivity of vehicles and transport staff. Over half of the respondents interviewed could not provide estimates of these losses. Most of the data on revenue losses was collected from the UK respondents. This analysis indicated that the users evaluated the losses to be about 2.2 times higher than the estimates provided by the VTT statistics. This multiplier provides an estimate of the additional costs of missed business opportunities and estimates of additional scheduling costs, which are not considered explicitly in the value of time figures.

By and large, the interviews with the industry experts confirmed that indirect costs (lost opportunities) did exist: on average the total (direct and indirect) costs to industry of the impediments to road transport were about twice the direct costs.

The possibility of high shipper VTTs was also indicated by the variation in outcomes by commodity type in the most recent Norwegian national freight VTT study (Halse et al., 2019). The weighted average value for the VTT in Norway is 13 NOK/tonne-hour (cargo component only), which in itself is not particularly high (about £1 per tonne-hour). This value refers all modes, not just road transport. However, it varies a lot between commodity groups: from 2 (timber) to 194 (fresh fish) NOK/tonne-hour. Therefore, it was recommended to apply values per commodity type in cost benefit analysis. Given that the Norwegian national freight transport model can produce forecasts per commodity group, this is a potential feasible approach going forward in other jurisdictions. The value of 13 NOK was derived as a weighted average using national freight transport model outcomes.

Conclusion on VTT

This study used questionnaires and SP designs that were similar to the ones used in the Netherlands in 2009-2010 and Norway 2018-2019. For carriers (time-dependent transport cost component), rather similar VTTs were obtained as in the Netherlands, but for shippers the UK values were substantially higher than both the Netherlands and the weighted average in Norway (though the Norwegian study also found commodities with high VTT for shippers). These high VTTs for shippers may be related to: capital invested in the goods, deterioration of the goods during transport, loss of shelf life for goods arriving late, disruption of production process for goods arriving late and suboptimal logistics (bigger inventories, number and location of depots) due to longer travel times.

Some previous studies that investigated shippers with potentially high VTTs found them to be as such. The key question then is why these factors explaining high shipper VTTs have not been reflected in the previous national freight VTT studies, especially the one in the Netherlands. The most plausible explanation is that the Dutch study was carried out thirteen years ago and that since then further changes in supply chain/delivery cultures have taken place towards more time-sensitive deliveries of goods, not just for some high-value goods, but on a wide scale in terms of commodities involved: in many supply chains requirements in terms of delivery time have become tighter, inventories have been reduced and the importance of fine-grained scheduling has increased. The UK is one of the leading countries (with for instance the US, Japan, South-Korea) in this move towards a greater time sensitivity of goods deliveries, suggesting a particular reason why this study may have been higher.

6.2.2 Derived freight VTTR compared to others

Previous studies

There are different ways to express the relationship between VTTR and VTT. The most practical one (de Jong and Bliemer, 2015) is probably the reliability ratio: VTTR/VTT, where the VTTR is for the standard deviation of transport time (in the same time units as the VTT, normally hours). In Table 3 below are some results for this metric from the literature.

Table 3: VTTR for freight transport by road

Reliability ratio (with standard deviation)				
MVA (1996)	UK	Literature review		Road transport: 1.2
Halse et al. (2010)	Norway	SP (mainly shippers in road transport)	Multinomial logit (MNL)	Shippers using road transport: 1.2 Carriers (road): 0 Overall reliability ratio for road: 0.1
Significance et al. (2013)	Netherlands	SP survey among shippers and carriers	MNL	Shippers using road transport: 0.3-0.9 Carriers (road): 0 Overall reliability ratio for road: 0.4 Also values for rail, inland waterways, sea and air transport.
Fowkes (2006, 2015)	UK	SP (LASP interview) among shippers using or potentially using rail	Manual method and weighted regression	0.66 -1.40 for coal 0.41 – 1.33 for metals 1.22 – 2.12 for aggregates 1.51 – 2.00 for oil and chemicals 1.35 – 1.81 for automotive 1.53 – 2.35 for other bulks 0.94 – 1.56 for container 0.79 – 1.32 for finished goods 2.79 – 2.93 for express goods
Wallis and King (2019)	New Zealand	Open-ended contingent valuation		5.6 for shippers
Halse et al. (2019)	Norway	SP	MNL	0.1 – 0.6 (overall 0.23)

For shippers (cargo component), values for the reliability ratio (RR) around 1 were not unusual. For carriers (transport cost component), several studies did not find a significant VTTR, although theoretically there can be benefits for the carriers when they would have less uncertainty about the transport time and thus more certainty about their vehicle scheduling. The overall (shipper and carrier) VTTR therefore was rather low (0.1 – 0.4), given that these came from studies where the transport costs component of the VTT exceeded the cargo component of the VTT, so the carrier component weighs more.

Conclusion on VTTR

In this study we obtained a RR of 0.6-0.7 for carriers and 0.2 for shippers. When compared to the above literature, this is a relatively high ratio for carriers and a low one for shippers. The latter finding is related to the fact that we find a relatively high VTT for shippers; the new UK VTTRs are of the same order of magnitude as in the Netherlands and Norway. The total VTTR was around £55 pounds per vehicle per hour, which gives an RR of 0.4 for loaded transports (with a VTT of around £130). For empty transports, the VTTR was £45 and the RR 0.7. For all transports, the RR was around 0.4, similar to the 0.4 found in the Netherlands. It also aligns with the current TAG RR for cars and OGVs on urban roads of 0.4 and 0.6 for OGVs on interurban strategic roads.

6.3 Assurance summary

The survey met the target number of 600 responses and navigated a challenging 2022 spring/summer for the industry with an extended survey period, a hiatus in the August, and a targeted approach to meet quotas for the subsamples. 50 responses for each of the subsamples were not achieved however the analysis foresaw this risk and pivoted to respond as set out in Section 5.

The output VTTs are shown to be high when compared with international studies but are within the bounds of the range of values seen. The higher values can be explained, in part, by the macroeconomic influences at the time of the survey. However, given the scale of the study as the largest of its kind in the UK, the sample should be considered robust and therefore reflects UK market conditions, which are increasingly time sensitive.

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A.1 Stated preference design

The stated preference design was set out in Technical Note 2.1b, an output of work package 2. Technical Note 2.1b reports on the chosen methodology for construction of the SP designs. These SP designs are the underlying tables that determine which values are shown for each attribute in each question of the choice experiment.

The remainder of this Appendix is the contents of Technical Note 2.1b.

Each respondent will participate in two choice experiments:

- SP1: a two-attribute experiment with time and cost.
- SP2: a three-attribute experiment with time, cost and reliability.

Each experiment will consist of eight choice situations for which we ask the respondent to indicate which of the two alternatives (s)he prefers. In addition, the second experiment will contain a choice situation in which all attributes of one alternative are better than those of the other alternative. This 'dominant question' (a question with a dominating alternative) is used as a check to see whether the respondent has understood the experiment and will be used to filter respondents for both experiments.

We discuss the methodology for SP1 and SP2 respectively in Section 1 and Section 2 of this technical note.

Design of SP1

In each choice task, the respondent is asked to make a choice between two route alternatives A and B, each described in terms of a travel time (T) and cost (C). The ratio of the cost and time difference between these two alternatives is called the boundary value of time (BVTT):

$$BVTT = -\frac{C_B - C_A}{T_B - T_A}$$

If the respondent's value of time (VTT, reported in pence per minute or pounds per hour) is lower than the BVTT, (s)he will generally prefer the slower and cheaper alternative. If it is higher, (s)he will generally prefer the quicker and more expensive alternative.

Step 1: General approach

In the most recent passenger VTT studies in Norway and Sweden, the so-called "Nordic" design has been used successfully. The basic characteristic of this design is that each respondent sees a series of choice pairs with a broad BVTT-range. This BVTT-range is subdivided into several intervals and the design is such that every respondent sees (at least) one choice task with a BVTT in each of these intervals. This means that every respondent will get a choice task with a (relatively) large time difference and a small cost difference (i.e. a low BVTT) and a choice task with a (relatively) small time difference and a large cost difference (i.e. a high BVTT). This ensures that most respondents will "trade" between alternatives. This means that they sometimes choose the cheap/slow alternative and sometimes choose the expensive/fast alternative, which allows for unbiased and stable VTT estimations.

The recent UK passenger VTT study used a very different strategy: their design was optimised based on D-efficiency, without considering the BVTT-range. The main advantage of this approach is efficiency, i.e. obtaining coefficients as accurately as possible for a given number of respondents. A disadvantage of the approach could be that the upper bound on the VTT cannot be defined, complicating the characterisation of travellers with a high VTT (i.e. the upper tail of the distribution).

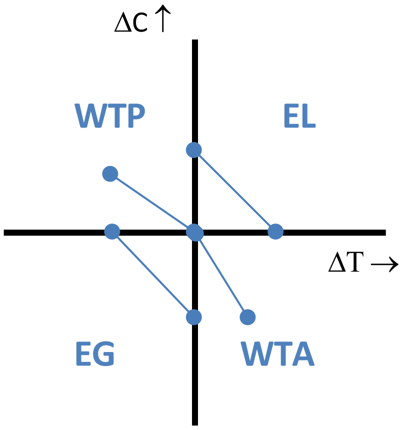
In SP1 we apply the Nordic design strategy. In a two-attribute experiment it is particularly important to cover a broad BVTT-range and, consequently, get a high percentage of "traders". The danger of applying a D-efficiency strategy in a two-attribute experiment is that the design is only efficient for respondents with a VTT close to the average in the population. Especially in freight transport, we expect a broad range of VTTs amongst the respondents and the Nordic design is better suited for that situation.

Step 2: Reference-based or not

Another important decision to take is whether the choice pairs should be reference-based or not. This allows us to easily correct for reference dependency, such as a different valuation of time gains and losses. In a reference-based design, each choice pair is in one of the following quadrants (also see Figure 9).

- Willingness-To-Pay (WTP): a choice between the reference trip and a faster and more expensive trip;
- Willingness-To-Accept (WTA): a choice between the reference trip and a slower and cheaper trip;
- Equivalent Gain (EG): a choice between a refence trip that is faster and a reference trip that is cheaper
- Equivalent Loss (EL): a choice between a refence trip that is slower and a reference trip that is more expensive.

Figure 9: Four quadrants of reference-based choice pairs. The centre point refers to the reference trip.



This approach has been used in most of the recent European passenger VTT studies (Norway 2009, 2018; Sweden 2008, Netherlands 2009/11) and has the advantage that it is simple, both for the respondents and for the analyst. However, with this design it is not completely possible to disentangle the status-quo effects and the dependence of the VTT on ΔT and ΔC. The recent UK study was not limited to only reference-based choice pairs. As a result, the reference-dependency of the choice behaviour of the respondents (de Borger & Fosgerau, 2008) could be studied in more detail. However, this required the estimation of a complex utility function. This turned out to be a challenge. So, there are advantages and disadvantages to both approaches.

For this study, we have chosen to use only reference-based choice pairs. A key reason for doing so is that the expected sample sizes are smaller in the context of freight than for passenger transport such that it will not be possible to use the complex utility function from the UK passenger study.

The eight SP1 questions will be balanced over the four quadrants, meaning that every respondent gets two WTP questions, two EL questions, two EG questions and two WTA questions.

Step 3: Segmentation

For the SP designs and/or the sampling we distinguish the following types of segmentation in this study:

1. Company type:
   - Carrier
   - Shipper (own-account)
   - Shipper (hire-and-reward)

2. Value density of goods:
    - High
    - Medium
    - Low
    - Perishable
3. Vehicle type:
    - LGV (Light Goods Vehicle, up to 3.5 tons gross vehicle weight, average carrying capacity of 1 ton)
    - OGV1 (Heavy Goods Vehicle, more than 3.5 up and up to 26 tons gross vehicle weight, average carrying capacity of 8 ton)
    - OGV2 (Heavy Goods Vehicle, more than 26 tons gross vehicle weight, average carrying capacity of 20 ton)
4. Routing / Direction:
    - To a port, an airport or the Channel Tunnel
    - Not to a port, an airport or the Channel Tunnel.

Step 4: BVTT range

Based on the findings in Technical Note 1.1 and the most recent Norwegian freight VTT study we arrive at the BVTT ranges in

Table 45. For practical reasons we made the lower and upper bounds scalable; in the remainder of this report we call this scale factor *BVTTfac*.

Table 45: BVTT-range for the different segments

	BVTT-range (£/ton/hour)			
Goods value	**Low-value**	**Medium-value**	**High-value**	**Perishable**
Carrier	1.0 – 74.0 *(BVTTfac = 1.0)*	1.0 – 74.0 *(BVTTfac = 1.0)*	1.0 – 74.0 *(BVTTfac = 1.0)*	1.0 – 74.0 *(BVTTfac = 1.0)*
Shipper (own-account)	1.1 – 81.4 *(BVTTfac = 1.1)*	1.15 – 85.1 *(BVTTfac = 1.15)*	1.25 – 92.5 *(BVTTfac = 1.25)*	1.4 – 103.6 *(BVTTfac = 1.4)*
Shipper (hire-and-reward, Light Goods Vehicle)	0.2 – 14.8 *(BVTTfac = 0.2)*	0.3 – 22.2 *(BVTTfac = 0.3)*	0.4 – 29.6 *(BVTTfac = 0.4)*	0.5 – 37.0 *(BVTTfac = 0.5)*
Shipper (hire-and-reward, Other Goods Vehicle)	0.1 - 7.4 *(BVTTfac = 0.1)*	0.15 – 11.1 *(BVTTfac = 0.15)*	0.25 – 18.5 *(BVTTfac = 0.25)*	0.4 – 29.6 *(BVTTfac = 0.4)*

For the transport component (i.e. carriers) and the goods component (i.e. hire-and-reward shippers) we expect a VTT of roughly £7/ton/hour and £1/ton/hour, this is based on the values from the European literature, as summarised in Table 6 in Technical Note 1.1. We define a wide BVTT-range of £1-74/ton/hour around the expected BVTT of £7/ton/hour for the carriers. The BVTT-range for carriers is not dependent on goods value, as for carriers the goods component is not part of the scope of the survey. For the hire-and-reward shippers the probed BVTTs are a lot smaller than for carriers: depending on the goods value, a factor of 0.1, 0.15, 0.25 or 0.4. For transports for hire-and-reward shippers that are carried out with a light goods vehicle, we use slightly higher BVTT values, as costs per ton tend to be higher when transported with smaller vehicle. The differences between the goods value groups are based on the most recent Norwegian freight VTT study. For own-account shippers both the transport component and goods component matters, which is why the BVTT-ranges are a sum of the BVTT-ranges for carriers and hire-and-reward shippers.

Note that the minimum and maximum of the BVTT-range as set in Table 1 has implications for the minimum and maximum differences for the time and cost attributes, since:

$$\min(BVTT) = \frac{minimum\ cost\ difference}{maximum\ time\ difference} = \frac{min(abs(C_A - C_B))}{max(abs(T_A - T_B))} \qquad [1]$$

$$\max(BVTT) = \frac{maximum\ cost\ difference}{minimum\ time\ difference} = \frac{max(abs(C_A - C_B))}{min(abs(T_A - T_B))} \qquad [2]$$

Step 5: Set range of values for the time attribute

In this step we set the possible values of the time-attribute (T) for the different segments.

We start by setting the T-levels for a respondent with a typical base time (i.e. the observed time of his reference transport). As typical base time we take 180 minutes.[10] We choose an array of nine different T-levels in order to be able to get a large variety of BVTT-values. Since we are using a reference-based approach, one of the levels is the base time. The remaining eight levels are spread symmetrically around the base time (Table 46).

Table 46: The time levels in SP1 for a respondent with a base time of 180 minutes

	Time levels (minutes)								
Level	**-4**	**-3**	**-2**	**-1**	**0**	**1**	**2**	**3**	**4**
Time	140	156	164	172	180	188	196	204	220
DeltaT	-40	-24	-16	-8	0	8	16	24	40

For respondents with other base times:

$$T = BaseTime + deltaT$$

The easiest way to set the range of *deltaT* values for respondents with other base times is to scale them proportionally to the levels for a respondent with a 180-minute base time. However, this causes the range of *deltaT* (i.e. the difference between the T-level and the base time) to scale proportionally with the base time. Previous studies have shown that the VTT depends both on the base time and on the size of *deltaT*. If in the design *deltaT* is highly correlated with the base time, it will be very hard to distinguish the base time effect from the *deltaT*-effect. Therefore, we need to 'break' the correlation between *deltaT* and base time in the design. We do this by using Table 47 for *deltaT* depending on base time, the time levels from Table 46 are multiplied with *BaseTimeFac* in this table. Multiplying with one of the eight specified *BaseTimeFac* values instead of a continuous factor (i.e. BaseTime/180) ensures that the *deltaT* does not depend linearly on the base time anymore. This reduces the correlation between *deltaT* and base time.

[10] We choose this value because in the Norwegian study the average base time is about four hours. Norway is less dense than the UK and that study was about transport chains, while we only look at a single transport leg of a chain. Therefore, we take a value lower than in the Norwegian study

Table 61, at the end of this memo, summarizes which multiplicative factors should be applied to which attributes.

Table 47: The time levels in SP1 for respondents with other base times

Base time (minutes)	Typical base time	*BaseTimeFac* Scale factor with respect to base time = 180	deltaT levels (in min.)								
			-4	-3	-2	-1	0	1	2	3	4
10 - 33	23	0.125	-5	-3	-2	-1	0	1	2	3	5
34 - 67	45	0.25	-10	-6	-4	-2	0	2	4	6	10
68 - 134	90	0.5	-20	-12	-8	-4	0	4	8	12	20
135 - 269	180	1	-40	-24	-16	-8	0	8	16	24	40
270 - 539	360	2	-80	-48	-32	-16	0	16	32	48	80
540 - 1079	720	4	-160	-96	-64	-32	0	32	64	96	160
1080 - 2159	1440	8	-320	-192	-128	-64	0	64	128	192	320
2160+	2880	16	-640	-384	-256	-128	0	128	256	384	640

Step 6: Set range of values for the cost attribute

In the SP experiments the cost levels are relative to the base cost (i.e. the travel cost of the reference transport). In the survey we ask for the cost of transporting the shipment in the reference trip in pounds. However, we want to control the BVTT in terms of £/ton/hour. Therefore, we need the base cost in £/ton for the SP experiments (we call this *BaseCostPerTon*). If the cost in £ per shipment is filled out in the survey, we divide this cost by the shipment weight to get *BaseCostPerTon*. If the cost in £ per shipment is not filled out in the survey, we present our own estimate of the transport cost for the shipment to the respondent[11]. The respondent is asked whether (s)he agrees with the estimate and if not, allowed to correct the estimate. The resulting entry for transport cost (our own estimate or the respondent-corrected estimate) can then be processed in the same way as transport costs given near the start of the survey.

The costs in the SP experiments refer to the total costs of the shipment. However, the design is based on the cost differences per ton (deltaCperTon). So, we have:

$$Cost = (BaseCostPerTon + deltaCperTon) \times Weight$$

where *Weight* is the shipment size (in tons).

For the actual levels of *deltaCperTon* (difference between the cost value and the base cost, in £/ton) we use the values in Table 48. These values apply to a respondent from segment carrier/low-value with a base time of 180 minutes. As with the time attribute, we choose nine different levels consisting of the base cost and eight cost levels spread symmetrically around *BaseCostPerTon*.

Table 48: The *deltaCperTon* levels

	Cost levels (in £/ton)								
Level	**-4**	**-3**	**-2**	**-1**	**0**	**1**	**2**	**3**	**4**
Cost									
deltaCperTon	-9.87	-2.50	-1.00	-0.67	0	+0.67	+1.00	+2.50	+9.87
	x BaseTimeFac x BVTTfac								

(The deltaCperTon levels need to be multiplied by the BaseTimeFac and segment-specific BVTTfac)

[11] For this we provisionally propose using £20/ton/h for LGV, £10/ton/h for OGV1 and £5/ton/h for OGV2 for both shippers and carriers. This is based on the expected VTT from Technical Note 1.1 and the economies of scale of using larger vehicles.

For respondents with other base times, the same scale factors apply as in Table 47. In this way, the BVTT range is always the same, irrespective of the base time and base cost. For respondents in other segments, the deltaC values in Table 48 need to be multiplied with the scale factors (BVTTfac) from

Table 45.

$$deltaCperTon = deltaCperTonCarrierLow180 \times BaseTimeFac \times BVTTfac \qquad [3]$$

Since the *deltaCperTon* values only depend on the *BaseTimeFac* and the *BVTTfac* and not on the size of the current cost level of the respondent (BaseCost), it is possible that the cost level (i.e. *BaseCostPerTon* + *deltaCperTon*) becomes very small or even negative. This needs to be prevented by setting the minimum values for the sum (*BaseCostPerTon* + *deltaCperTon*) as shown in Table 49.

Table 49. The minimum cost levels

	Minimum cost levels (in £/ton)								
Level	**-4**	**-3**	**-2**	**-1**	**0**	**1**	**2**	**3**	**4**
Minimum cost level	0.50	0.87	0.95	0.97	1.00	1.03	1.05	1.13	1.50
	x BaseTimeFac x BVTTfac								

Shippers that contract out, shippers that carry out transport on own account and carriers have similar transport costs (in practice there will be rather minor differences due to profit margins, which are small in the road freight transport sector, and economies of scale). However, they will have clearly different VTTs and therefore also different BVTTs. Therefore, we have to present other (smaller) changes in attributes to the shippers that contract out than to the other two groups. We propose to send the same time changes to all three groups, but different cost changes: the cost changes are smallest for the hire-and-reward shippers; and are highest for the own account shippers (for which they are slightly larger than for carriers). This is arranged through the *BVTTfac* as shown above in Equation 3.

Step 7: Rounding

All travel times shown will be rounded to the nearest multiple of 1 minute if the BaseTime is smaller than 4 hours, otherwise the travel times will be rounded to the nearest multiple of 5 minutes.

All shown travel costs (per shipment, not per ton) will be rounded to the nearest multiple of £0.05 if the BaseCost is smaller than £20, to the nearest multiple of £0.20 if the BaseCost is smaller than £100, and to the nearest multiple of £1 otherwise.

Step 8: Creating the design tables

We have nine time levels x nine cost levels, of which one time level and one cost level are equal to the reference level. Given that we have a reference-based design, each choice pair contains one alternative with the reference time and one alternative (could be the same) with the reference cost level. For the other time and cost level, eight possibilities exist, giving 64 possible choice pairs. These can be distributed over eight blocks x eight questions, so we construct the full design within these constraints. The design for SP1 is shown in

Table 50.

Step 9: Additional randomisation

For each respondent, the order of the eight choice questions within the block (s)he is assigned to, is randomised. Furthermore, the A and B alternative (as defined in our design table) should be randomly presented as the left and right alternative in the choice screen. Table 62, at the end of this section, summarizes the randomisation rules for SP1.

Table 50. The design table for SP1

Block	Question	deltaT (A)	deltaCperTon (A)	deltaT (B)	deltaCperTon (B)	BVTTperTon [£/ton/h]
1	1	-40	0	0	-0.67	1.01
1	2	24	0	0	1	2.50
1	3	16	-1	0	0	3.75
1	4	-8	1	0	0	7.50
1	5	-40	0	0	-9.87	14.81
1	6	24	0	0	2.5	6.25
1	7	16	-2.5	0	0	9.38
1	8	-8	2.5	0	0	18.75
2	1	-40	0.67	0	0	1.01
2	2	-24	0	0	-0.67	1.68
2	3	16	0	0	1	3.75
2	4	8	-1	0	0	7.50
2	5	-40	9.87	0	0	14.81
2	6	-24	0	0	-9.87	24.68
2	7	16	0	0	2.5	9.38
2	8	8	-2.5	0	0	18.75
3	1	40	-0.67	0	0	1.01
3	2	-24	0.67	0	0	1.68
3	3	-16	0	0	-0.67	2.51
3	4	8	0	0	1	7.50
3	5	40	-9.87	0	0	14.81
3	6	-24	9.87	0	0	24.68
3	7	-16	0	0	-9.87	37.01
3	8	8	0	0	2.5	18.75
4	1	40	0	0	0.67	1.01
4	2	24	-0.67	0	0	1.68
4	3	-16	0.67	0	0	2.51
4	4	-8	0	0	-0.67	5.03
4	5	40	0	0	9.87	14.81
4	6	24	-9.87	0	0	24.68
4	7	-16	9.87	0	0	37.01
4	8	-8	0	0	-9.87	74.03
5	1	-40	0	0	-1	1.50
5	2	24	0	0	0.67	1.68
5	3	16	-0.67	0	0	2.51
5	4	-8	0.67	0	0	5.03
5	5	-40	0	0	-2.5	3.75
5	6	24	0	0	9.87	24.68
5	7	16	-9.87	0	0	37.01
5	8	-8	9.87	0	0	74.03
6	1	-40	1	0	0	1.50
6	2	-24	0	0	-1	2.50
6	3	16	0	0	0.67	2.51
6	4	8	-0.67	0	0	5.03
6	5	-40	2.5	0	0	3.75
6	6	-24	0	0	-2.5	6.25
6	7	16	0	0	9.87	37.01
6	8	8	-9.87	0	0	74.03
7	1	40	-1	0	0	1.50
7	2	-24	1	0	0	2.50
7	3	-16	0	0	-1	3.75
7	4	8	0	0	0.67	5.03
7	5	40	-2.5	0	0	3.75
7	6	-24	2.5	0	0	6.25
7	7	-16	0	0	-2.5	9.38
7	8	8	0	0	9.87	74.03
8	1	40	0	0	1	1.50
8	2	24	-1	0	0	2.50
8	3	-16	1	0	0	3.75
8	4	-8	0	0	-1	7.50
8	5	40	0	0	2.5	3.75
8	6	24	-2.5	0	0	6.25
8	7	-16	2.5	0	0	9.38
8	8	-8	0	0	-2.5	18.75

Table 51. The presented values in SP1 for a carrier (assigned to block 4) with a BaseTime of 180 minutes, a shipment of 10 tonnes and a BaseCostPerTon of 5£/ton.

Block	Question	Time (A) [min.]	Cost (A) [£]	Time (B) [min.]	Cost (B) [£]	BVTT [£/h.]
4	1	220	50.00	180	56.80	10.20
4	2	204	43.20	180	50.00	17.00
4	3	164	56.80	180	50.00	25.50
4	4	172	50.00	180	43.20	51.00
4	5	220	50.00	180	148.80	148.20
4	6	204	5.00	180	50.00	112.50
4	7	164	148.80	180	50.00	370.50
4	8	172	50.00	180	5.00	337.50

Design of SP2

Step 1: General design strategy

With this experiment, we want to determine the value-of-travel time reliability (VTTR). The expected range of the VTTR is even larger than the expected range of the VTT. However, we can also express the value-of-travel time reliability in terms of the reliability ratio:

RR = VTTR / VTT [4]

The expected range for the RR is very limited. Based on mixed logit estimations with loguniform-distributed parameters on the Dutch passenger VTT data from the 2011 survey, we have found that in almost all segments the RR is expected to be between 0.05 and 5.

To determine the RR, it is sufficient to have an SP experiment with only time and reliability (i.e. no variation in the cost attribute between the two alternatives). Therefore, four out of the eight choice pairs in this experiment will be of the time vs. reliability type (called SP2A), in which we further ensure that the whole RR-range is covered by these choices. So, this will be the equivalent of the Nordic-type design strategy. In this way, the shape of the distribution of the RR within the population can be determined and a correct and unbiased average can be estimated.

The remaining four questions will be used to ensure that we can jointly estimate models on both SP1 and SP2-data. Therefore, these SP choice cards have variable travel times, travel time reliabilities and travel costs (called SP2B). Since this is now an experiment with three variable attributes (rather than two as are in SP1 and SP2a), we cannot use the Nordic design strategy.[12] The design for these four questions will be optimised for D-efficiency to maximise the accuracy of the estimated coefficients.

Respondents receive four questions of SP2A and four questions of SP2B. However, respondents will not see the difference. The cost attribute is left out of the SP2A design, but the base cost will be shown as the cost for both alternatives in these questions.

Since we do not have (a good estimate of) a respondent's current level of reliability, we cannot use a reference-based design. So, all choice pairs will be non-reference-based.

Step 2: Segmentation

We use the same segmentation as defined for SP1.

Step 3: Set the BRR-range

For the four choice pairs of the type Time vs. Reliability (SP2A), we need to set the Boundary RR (BRR) range. The minimum and maximum RR are used to set minimum and maximum steps for the *deltaT* and the

[12] In principle, it is possible to use a Nordic design strategy with three attributes. However, to cover the whole attribute range in three independent dimensions would require a very large number of choice questions. This makes such a design very unattractive in practice.

deltaReliability levels. The reliability is here defined as the standard deviation of the travel time distribution. The BRR-ranges are as shown in Table 52. For carriers and own-account shippers we expect a lower RR-range because their expected VTT is already very high (note that RR = VTTR/VTT).

In order to keep the minimum BRR at a constant level of 0.05 for each segment, the BRRfac should be kept 1.0 for the first question of each block (the first question has the lowest BRR within each block).

Table 52: BRR-range for different segments.

	BRR-range	
	Not to port	**To port**
Carrier	0.05 – 2.00 *(BRRfac = 1.0)*	0.05 – 2.00 *(BRRfac = 1.0)*
Shipper (own-account)	0.05 – 2.00 *(BRRfac = 1.0)*	0.05 – 3.00 *(BRRfac = 1.5)*
Shipper (hire-and-reward)	0.05 – 3.00 *(BRRfac = 1.5)*	0.05 – 4.00 *(BRRfac = 2.0)*

The obtained BRR-range depends on deltaTime and deltaReliability as follows:

$$\min(BRR) = \frac{min(abs(T_A - T_B))}{max(abs(R_A - R_B))} \quad [5]$$

$$\max(BRR) = \frac{max(abs(T_A - T_B))}{min(abs(R_A - R_B))} \quad [6]$$

Step 4: Set the time levels

In Table 53 and Table 54 we see the time levels respectively for SP2A and SP2B for a respondent with a base time of 180 minutes. Just like in SP1, we multiply the *deltaT* with *BaseTimeFac* (see Table 47 for respondents with other base times. In addition, the *deltaT* is multiplied by *BRRfac* (see Table 52) in order to probe the right BRR-range for each segment.

Table 61, at the end of this memo, summarizes which multiplicative factors should be applied to which attributes. Levels -1 and +1 should always be at least one minute different from the base time.

Table 53: The time levels in SP2A for a respondent with a base time of 180 minutes.

	Time levels (in min.)								
Level	**-4**	**-3**	**-2**	**-1**	**0**	**1**	**2**	**3**	**4**
Time	160	164	170	178	180	182	190	196	200
Difference from base time	-20	-16	-10	-2	0	2	10	16	20

Table 54: The time levels in SP2B for a respondent with a base time of 180 minutes.

	Time levels (in min.)								
Level	**-4**	**-3**	**-2**	**-1**	**0**	**1**	**2**	**3**	**4**
Time	140	156	164	172	180	188	196	204	220
Difference from base time	-40	-24	-16	-8	0	8	16	24	40

Step 5: Set the reliability levels

This is the standard deviation (*Stdev*) of the travel time distribution that will be shown. In Step 7 we will explain how we convert this standard deviation to the five possible travel times.

The *Stdev* levels are equal to those in Table 55, note that the levels must be multiplied with the *BaseTimeFac* as defined in Table 47.

This reliability can also be expressed as the ratio between the standard deviation and the average travel time itself. This is called the coefficient of variation (c.o.v.):

c.o.v. = stdev / Time [7]

The maximum c.o.v. should not be too large, since this will give very unrealistic variation of travel times. In the 2009/11 Dutch passenger VTT/VTTR survey, the maximum c.o.v. was 0.61, which was considered very unrealistic. If some combinations lead to a c.o.v. that is considered too high, these will be excluded.

Table 55: The reliability levels in SP2

	Stdev levels (minutes)			
Level	**1**	**2**	**3**	**4**
Stdev	4	14	28	48
	x BaseTimeFac			

Step 6: Set the cost levels

These cost levels are only necessary for the choice pairs of type time vs. reliability vs. cost (SP2B). We will use the same levels and method as in SP1 (see Table 48 and Table 49).

Step 7: Converting standard deviation to five possible travel times

Given a standard deviation and a (mean) travel time, which both follow from the design tables, one could easily determine five possible travel times by taking the 10%, 30%, 50%, 70% and 90% percentile from the travel time distribution with the aforementioned mean and standard deviation. However, it is not clear which distribution is to be taken. This can range from a symmetric normal distribution to an extremely skewed distribution with a long tail towards long travel times.

Since we do not want to fix this distribution, for each choice alternative a random draw determines which of the following four distributions is assumed: normal, lognormal, skewed, extremely skewed. To give an idea what this looks like, Table 56 presents the five possible travel times for the four distributions for a mean of

180 minutes and a standard deviation of 21 minutes. For any other combination of mean and standard deviation, the five possible travel times are calculated with the following equation:

$$PossibleTravelTime = Mean + Stdev \text{ x } DistributionFactor$$

with the *DistributionFactors* as given in the lower part of Table 56.

Table 56: Five possible travel times based on the DistributionFactors and distribution type

	Normal (1)	Lognormal (2)	Skewed (3)	Extremely skewed (4)
Five possible travel times	151	153	157	164
	168	168	168	166
	180	177	173	168
	192	191	189	186
	209	212	214	217
Mean	180	180	180	180
Stdev	20	20	20	20
Skewness	0	0.45	0.95	1.5
Five DistributionFactors	-1.45833	-1.33333	-1.16667	-0.79167
	-0.60833	-0.625	-0.625	-0.70833
	0	-0.16667	-0.375	-0.625
	0.60833	0.54167	0.45833	0.29167
	1.45833	1.58333	1.70833	1.83333

Step 8: Rounding

All shown travel times will be rounded to the nearest multiple of 1 minute if the *BaseTime* is smaller than 4 hours, otherwise the shown travel times will be rounded to the nearest multiple of 5 minutes.

All shown travel costs (per shipment, not per ton) will be rounded to the nearest multiple of £0.05 if the *BaseCost* is smaller than £20, to the nearest multiple of £0.20 if the BaseCost is smaller than £100, and to the nearest multiple of £1 otherwise.

Step 9: Creating the design tables

The designs for SP2A (time-reliability) will be of the “Nordic” type. This is similar to SP1, but instead of focussing on a wide BVTT-range, we focus on getting a wide BRR-range.

The designs for SP2B are optimised for so-called D-efficiency. This means that we use a software package (Ngene) to find a set of choice questions with specific attribute values that will lead to the highest accuracy (i.e. smallest uncertainty margins) given the (limited) number of respondents. For this purpose, prior estimates are obtained from the most recent Dutch freight VTT/VTTR study. These prior estimates can be updated with the results from this pilot study.

Table 57 shows the design table for SP2. Note that the design table for SP2 consists of 6 blocks, in contrast to the 8 blocks of SP1, this is due to the limited number of possible combinations of attribute levels for SP2A. Furthermore, in each block we add a ninth question, which is the same regardless of the block number. This is the dominant question, which we use to check whether respondents made rational choices. The distribution types of the left and right alternative should both be ‘lognormal (2)’ in the dominant question.

Table 57. The design table for SP2

Block	Question	deltaT (A)	deltaCperTon (A)	Stdev (A)	deltaT (B)	deltaCperTon (B)	Stdev (B)
1	1	0	0	48	2	0	4
1	2	10	0	4	0	0	48
1	3	20	0	14	0	0	48
1	4	20	0	14	0	0	28
1	5	0	-0,67	48	-40	0	4
1	6	0	-9,87	48	-8	0	28
1	7	8	0	4	0	2,5	48
1	8	0	0,67	4	40	0	48
1	9	0	2,5	14	-24	0	4
2	1	-2	0	48	0	0	4
2	2	16	0	4	0	0	48
2	3	-20	0	28	0	0	4
2	4	0	0	14	-20	0	28
2	5	24	0	48	0	1	4
2	6	-8	9,87	14	0	0	48
2	7	0	0	48	16	-2,5	4
2	8	-24	0	28	0	-1	4
2	9	0	2,5	14	-24	0	4
3	1	0	0	48	2	0	14
3	2	0	0	28	10	0	4
3	3	20	0	4	0	0	28
3	4	0	0	4	-16	0	14
3	5	8	0	48	0	9,87	4
3	6	0	0	4	-24	-2,5	28
3	7	-40	0	28	0	0,67	4
3	8	0	0	4	24	-0,67	48
3	9	0	2,5	14	-24	0	4
4	1	-2	0	48	0	0	14
4	2	-10	0	28	0	0	4
4	3	0	0	4	-10	0	14
4	4	16	0	4	0	0	14
4	5	-24	0	4	0	-0,67	48
4	6	-16	0	14	0	-9,87	48
4	7	0	-2,5	48	24	0	14
4	8	0	0	48	-16	2,5	4
4	9	0	2,5	14	-24	0	4
5	1	2	0	28	0	0	48
5	2	0	0	48	20	0	4
5	3	-16	0	28	0	0	14
5	4	0	0	4	-20	0	14
5	5	-8	2,5	4	0	0	48
5	6	0	-1	48	8	0	28
5	7	0	-9,87	14	-8	0	28
5	8	40	-2,5	48	0	0	28
5	9	0	2,5	14	-24	0	4
6	1	0	0	28	-2	0	48
6	2	16	0	14	0	0	48
6	3	0	0	28	16	0	14
6	4	20	0	4	0	0	14
6	5	24	1	14	0	0	48
6	6	0	-2,5	14	-24	0	28
6	7	0	2,5	4	40	0	48
6	8	0	0	48	8	-2,5	4
6	9	0	2,5	14	-24	0	4

To give an example, for an own-account shipper that transports a 10 tonnes medium-value shipment to a port in 120 minutes for 5 £/ton, the resulting values could be as shown in Table 58.

Table 58. The resulting values for a respondent as described above

	Left alternative	Right alternative
Average travel time	120 minutes	126 minutes
Five possible travel times	88 minutes 105 minutes 116 minutes 133 minutes 158 minutes	110 minutes 117 minutes 121 minutes 132 minutes 150 minutes
Cost	2.90 £	50.00 £

If we calculate the values of the dominant question for the same respondent, we get the following choice screen. Note how the travel time, standard deviation and cost of the right alternative are all lower (= better) than the right alternative. In addition, each of the five possible travel times is lower for the right alternative.

Table 59. The resulting values for the dominant question for a respondent as described above

	Left alternative	Right alternative
Average travel time	120 minutes	102 minutes
Five possible travel times	111 116 119 124 131	99 101 102 103 105
Cost	64.40 £	50.00 £

Step 10: Additional randomisation

For each respondent, the order of the nine choice questions within the block (s)he is assigned to, is randomised. Furthermore, the A and B alternative (as defined in our design table) should be randomly presented as the left and right alternative in the choice screen. The dominant question is an exception to these rules, here no left/right randomisation should be applied and the dominant question should always be the penultimate question. Table 62, at the end of this memo, summarizes the randomisation rules for SP2.

Summary of the proposed design method

The following table summarises the proposed method for the design (including the statistical design) of the SP experiments. In each of the interviews we propose to carry out two different SP experiments, SP1 (time and cost) and SP2 (also including reliability).

The output of the statistical SP design will consist of Tables (in Excel) that can be inserted in the programmed questionnaire as lookup tables to create the specific attribute levels that will be presented to each respondent in each choice situation of SP1 and SP2 during the interview.

Table 60: Summary of the key aspects of the SP design

Design aspect	SP1	SP2
Alternatives	Binary choice	Binary choice
Attributes	Transport time, transport cost	Transport time, transport cost, transport time reliability (presented as 5 equi-probable transport times)
Number of choice situations	8 pairs	8 pairs + 1 pair with a dominant alternative
Number of blocks	8 blocks	6 blocks
Statistical design method	Nordic design (broad range of boundary values)	4 choice pairs Nordic design: time versus reliability (with cost equal) = SP2A 4 choice pairs d-efficient design: time versus cost versus reliability = SP2B
Reference-based design	Yes	No
Segmentation in the design	Carrier, own account shipper, hire and reward shipper 4 types of goods (by value density)	Carrier, own account shipper, hire and reward shipper 4 types of goods (by value density) 2 types of direction (to a port and not to a port)
Time levels	Based on time of reference trip	Based on time of reference trip
Cost levels	Based on cost of reference trip	Based on cost of reference trip
Reliability levels	Not relevant	Not based on reliability of the reference trip
Cost units used	In presentation per transport/shipment In design per tonne	In presentation per transport/shipment In design per tonne
Rounding of values	Yes	Yes

The following two tables summarize which multiplicative factors (e.g. BaseTimeFac) should be applied to each variable in each experiment and which randomisation rules apply to which experiment.

Table 61: Summary of the multiplicative factors that should be applied to variables of each experiment

Experiment	Variable	BaseTimeFac	BVTTfac	BRRfac
SP1	deltaT	√		
SP1	deltaCperTon	√	√	
SP2	deltaT	√		√
SP2	deltaCperTon	√	√	
SP2	stDev	√		

Table 62: Summary of the randomisation rules in each experiment

Experiment	Randomisation rules
SP1	- Assign each respondent randomly to one of the eight blocks. - Randomise the order of the eight questions within the block for each respondent. - Randomise the left/right order of the A and B alternative in the design table for each question for each respondent.
SP2	- Assign each respondent randomly to one of the six blocks. - Randomise the order of the nine questions within the block for each respondent. Ensure that the ninth (dominant) question is the penultimate question in this order. - Randomise the left/right order of the A and B alternative in the design table for each question for each respondent. For the dominant question: keep the left/right order as in the design table. - Randomise which of the four distributions is used for converting the standard deviations to five possible travel times for each question and alternative. Except for the dominant question, here the two distribution types should always be: [A: lognormal, B: lognormal].

A.2 Survey questionnaire

INTRODUCTION (by mutual agreement with market research organisation)

ASK ALL

SINGLE CODE

Introduction question

AUTOMATIC CODE WITHIN THE PROGRAMME – NOT ASKED

Q0. Which of the following would you categorise yourself as?

☐ Haulier

☐ Shipper(a) who outsources ALL their transport

☐ Shipper(b) who PARTLY outsources transport

☐ Shipper (c) who does NOT outsource ANY transport

PART A: YOUR COMPANY

This survey consists of several parts. In this first part we like to ask you some questions about your company in general and its freight transport in particular.

ASK ALL

SINGLE CODE

A1.Which means of transport does your organisation use for freight transport (multiple answers possible)?

☐ road transport ☐ sea shipping

☐ rail ☐ airplane

☐ barge ☐ other

End of questionnaire if "road transport" is not selected.

ASK ALL

MULTIPLE CODE

A2. In which region in the UK is your company located (if multiple sites, then the location where you are responsible for the freight transport)?

☐	East Region	☐	Scotland
☐	East and West Midlands Region	☐	Wales
☐	North West Region	☐	Northern Ireland
☐	South East Region (including London)	☐	Outside UK

□	South West Region	□	All of the above
□	Yorkshire and the North East Region	□	

If outside of the UK, please include below:

____

ASK ALL

OPEN ENDED

A3. What is your job title within the organisation?

____

ASK ALL

SINGLE CODE

A4. How many employees does your organisation have? (Please include all permanent and contracted staff)

- □ 1 – 9
- □ 10 – 50
- □ 50 – 249
- □ 250 – 499
- □ 500 - 999
- □ 1000+

ASK IF Q0c = 1, 3, 4

MULTIPLE CODE

A5_1. Which products do you commonly transport (multiple answers are possible)?

Please tick all that apply

□	Agricultural (includes animal fodder/ livestock/ fertiliser)	□	Metals
□	Automotive (includes finished vehicles and parts)	□	Ores, aggregates and quarry products
□	Building materials	□	Perishable goods
□	Chemicals	□	Petroleum/ refined oil, coke
□	Coal (includes lignite/mineral fuels)	□	Retail (non-food)

- ◻ Food and drink (includes tobacco)
- ◻ General Haulage (includes Groupage)
- ◻ Glass, cement, other non-metallic minerals
- ◻ Manufactured goods
- ◻ Mail and parcels
- ◻ Utilities (includes gas/ water/ electric/ communications)
- ◻ Waste
- ◻ Other freight (please specify)

ASK IF Q0c = 2

MULTIPLE CODE

A5_2. Which products do you commonly have transported (multiple answers are possible)?

Please tick all that apply

- ◻ Agricultural (includes animal fodder/ livestock/ fertiliser)
- ◻ Automotive (includes finished vehicles and parts)
- ◻ Building materials
- ◻ Chemicals
- ◻ Coal (includes lignite/mineral fuels)
- ◻ Food and drink (includes tobacco)
- ◻ General Haulage (includes Groupage)
- ◻ Glass, cement, other non-metallic minerals
- ◻ Manufactured goods
- ◻ Mail and parcels
- ◻ Metals
- ◻ Ores, aggregates and quarry products
- ◻ Perishable goods
- ◻ Petroleum/ refined oil, coke
- ◻ Retail (non-food)
- ◻ Utilities (includes gas/ water/ electric/ communications)
- ◻ Waste
- ◻ Other freight (please specify)

ASK ALL

SINGLE CODE

A6a. Does your organisation have its own road freight transport vehicles? (leased vehicles included)

no

yes

ASK IF A6a = 2

OPEN RESPONSE

A6b. If yes, please identify how many vehicles you have:

_____ Light Goods Vehicle (LGV) <= 3.5 tonnes gross vehicle weight (GVW)

_____ Other Goods Vehicle (OGV 1) > 3.5 tonnes and <= 26 tonnes GVW

Most rigid lorries and urban artics

_____ Other Goods Vehicle (OGV 2) > 26 tonnes GVW

8 wheeler heavy rigid lorries and most artics

ASK IF Q0c = 3

SINGLE CODE

A7. What percentage of your freight transport is subcontracted (%)?

0%

1% - 10%

11% - 20%

21% - 40%

41% - 60%

61% - 80%

81% >

PART B: YOUR TRANSPORT

Could you think of a 'TYPICAL' transport journey by road which is carried out REGULARLY by you? This concerns a shipment which is typical for your company/organisation in terms of weight, packaging, distance, destination, etc.

You can consider any journey taking place (partially or fully) in England.

All questions in part B apply to this journey.

ASK ALL

SINGLE CODE

B0. Was the chosen transport journey carried out on your own account or subcontracted?

Own account

Subcontract

ASK ALL

FEED IN RESPONSES SELECTED AT Q5a

SINGLE CODE

B1. Which product(s) is/are carried on this journey?

{ANSWER 1 @ CODE Q5a}

{ANSWER 1 @ CODE Q5a}

{ANSWER 1 @ CODE Q5a}

SAVE THIS UNDER THE LABEL PRODUCT

ASK ALL

OPEN RESPONSE

B2.What is the (average) weight of a delivery of this product in tonnes/kilograms/litres?

________ tonnes / kilograms/ litres *(cross what is not applicable)*

ASK ALL

SINGLE CODE

B3. On this chosen transport journey, if the product was perishable then please tick the appropriate box below. If not then please tick an estimate of the load value?

Perishable material

High value material (load > £50,000)

Medium value material (load > £5,000 but < £50,000)

Low value material (load < £5,000)

ASK ALL

SINGLE CODE

B4a. Was the chosen transport journey part of a transport chain?

No, the load was carried in one vehicle directly from the origin to the destination

Yes, several different road vehicles

Yes, the road transport was part of an intermodal chain including rail, inland waterways, short sea shipping or aviation.

IF CODE 1 at B4a, go directly to question B8

ASK IF CODE 2 or 3 at B4a

SINGLE CODE

B4b. How many legs are involved in this transport chain?

2 legs

3 legs

4 legs

5 legs

6 legs

7 legs

8 legs +

ASK ALL

MULTIPLE CODE

B5. Which modes of transport and road vehicles have been used in the transport chain? *Please tick all that apply*

☐ Road transport: LGV (<= 3.5 tonnes)

☐ Road transport: OGV 1 (> 3.5 tonnes and <= 26 tonnes)

☐ Road transport: OGV 2 (> 26 tonnes)

☐ sea shipping

☐ rail

☐ airplane

☐ barge

☐ other: ___________________

ASK ALL

OPEN RESPONSE

B6. Where is the starting point of the whole transport chain?

If in the UK then please include the first part of the postcode (e.g. WA15) if known, if not then please include the town name and county. If it is outside of the UK, then the country name is sufficient.

____

ASK ALL

OPEN RESPONSE

B7. Where is the final destination of the whole transport chain?

If in the UK then please include the first part of the postcode (e.g. WA15) if known, if not then please include the town name and county. If it is outside of the UK, then the country name is sufficient.

____

The following questions apply to the **road part** of the transport. For a journey using multiple road transport vehicles, please describe the leg with the **longest** transport distance within England.

ASK ALL

OPEN RESPONSE

B8. Where is the load picked up for your chosen road transport leg of the journey?

If in the UK then please include the first part of the postcode (e.g. WA15) if known, if not then please include the town name and county. If it is outside of the UK, then the country name is sufficient.

____

SAVE THIS UNDER THE LABEL ORIGIN

ASK ALL

SINGLE CODE

B9. The location where the load was picked up from is a:

Production facility

Distribution warehouse

port/ ferry terminal

airport

rail cargo terminal

Channel Tunnel

other, that is: _______________________

ASK ALL

OPEN RESPONSE

B10. Where was the load delivered to for your chosen road transport leg of the journey?

If in the UK then please include the first part of the postcode (e.g. WA15) if known, if not then please include the town name and county. If it is outside of the UK, then the country name is sufficient.

____

SAVE THIS UNDER THE LABEL DESTINATION

ASK ALL

SINGLE CODE

B11. The location where the transport was delivered is a:

Production facility

Distribution warehouse

Customer business premises

Customer household premises

Port/ ferry terminal

airport

rail cargo terminal

Channel Tunnel

other, that is: _______________

ASK ALL

OPEN RESPONSE

B12. How many miles is a single leg of the chosen journey from ORIGIN (B8) to DESTINATION (B10)?

(May be an estimate)

_______ miles per one-way transport

unknown

ASK ALL

SINGLE CODE

B13a. Which vehicle is used during this transport from ORIGIN to DESTINATION?

Light Goods Vehicle (LGV) <= 3.5 tonnes gross vehicle weight (GVW)

Other Goods Vehicle (OGV 1) > 3.5 tonnes and <= 26 tonnes GVW

Most rigid lorries and urban artics

Other Goods Vehicle (OGV 2) > 26 tonnes GVW

8 wheeler heavy rigid lorries and most artics

ASK ALL

OPEN ENDED RESPONSE FOR EACH ROW

B14. For the chosen single leg of the journey selected from ORIGIN to DESTINATION, please indicate the amount of time involved in the following:

B14a. Loading	____ hours ____ minutes
B14b. Normal Driving time to this leg	____ hours ____ minutes
B14c. Extra travel time to normal (e.g. because of congestion/ roadworks/ diversion on route)	____ hours ____ minutes
B14d. Rest breaks	____ hours ____ minutes
B14e. Unloading	____ hours ____ minutes
B14f. Total time	____ hours ____ minutes

We expect B14a – B14e to total up and equal your answer in B14f. If this is not the case, the programme will show you an error message.

ERROR MESSAGE TO BE DISPLAYED HERE IF :

B14a + B14b + B14c +B14d+ B14e+B14f DOES NOT EQUAL B14g.

Confirm with respondent that the total time is correct

ASK ALL

SINGLE CODE

B15. Are there requirements for delivery to be made by an exact time or during a time window?

(here we also consider whether delivery should take place at daytime or within factory/office opening hours)

yes, the exact time is of importance → *go to question B16b*

yes, the time window is of importance

no → *go to question B22*

ASK IF B15 = 2

OPEN RESPONSE

B16a. How long is the window within which delivery should take place?

________ hours ________ minutes

ASK IF B15 = 1 or B15=2

SINGLE CODE

B16b. At what point of the day is the delivery time/ delivery window for this chosen journey leg meant to be?

Overnight (10pm – 6am)

Weekday AM peak (6pm – 10am)

Weekday off peak (10am – 4pm)

Weekday PM peak (4pm – 7pm)

Weekday evening (7pm – 10pm)

Weekend (6am – 10pm)

ASK ALL

OPEN RESPONSE

B17. What percentage of shipments when completing this chosen single leg of the journey is not delivered at the agreed time (IF ANSWER 1 IN QUESTION B15) or within the time window (IF ANSWER 2 IN QUESTION B15)? (this may be an estimate; answers to the survey are treated anonymously)

________ %→ *if 0%, go to question B22a*

ASK IF MORE THAN 0% at B17

MULTIPLE CODE

B18. What causes these late deliveries? (multiple answers possible)

the product was not ready on time for transport

the transport vehicle arrived late at the origin point in ORIGIN

delay during loading

delay during transport

other, that is: _________________

ASK IF MORE THAN 0% at B17

OPEN RESPONSE

B19. If regularly late, what is the average delay?(this may be an estimate)?

________ hours and ________ minutes

ASK IF MORE THAN 0% at B17

OPEN RESPONSE

B20a. Are there penalty fees imposed to your company when the delivery is late?

yes

no

IF NO IS ANSWERED TO B20a THEN SKIP TO B22

ASK IF B20a = 1

SINGLE CODE

B20b. what are these fees?

£0 - £100

£101 - £200

£201 - £300

£301 - £400

£401 - £500

£501+

ASK ALL

SINGLE CODE

B21. Do you have insurance for this?

yes

no

ASK ALL

SINGLE CODE

B22. Who is paying for the haulage of this load?

company at origin

company at destination (customer)

other, state ______________

ASK IF B0 = 2

OPEN RESPONSE

B23a. Could you specify the typical tariff you pay for the transport on this single journey leg? If you do not know this precisely, your best estimate is sufficient because an answer to this question is very important for the remainder of the survey.

_________________pounds per single journey leg

(Please estimate, even if it is an approximation)

ASK IF IF B0 = 1

OPEN RESPONSE

B23b. Could you specify the typical transport costs you incur for this single journey leg? Please note that these costs should not include any costs for (empty) returns. If you do not know this precisely, your best estimate is sufficient because an answer to this question is very important for the remainder of the survey.

_________________pounds per single journey leg (Please estimate, even if it is an approximation)

THIS ANSWER IS THE BASE LEVEL FOR THE COSTS IN THE SP

ASK ALL

MULTIPLE CODE

B24. Which of the costs mentioned below are included in your answer to the previous question?

transport costs (fuel, personnel, depreciation and maintenance of equipment, administration), excluding loading/unloading

(if more than 1 answer in question A1) transport costs for other means of transport used for the same transport

insurances for loss or damage of freight

possible penalty fees (for example, imposed by the client)

international freight fees

custom duties

loading at ORIGIN

unloading at DESTINATION

transhipments at intermediate locations (= not at the origin or final destination)

other costs (please specify): ________________________________

ASK ALL

SINGLE CODE

B25a. How has the fee you receive or pay for this journey been determined?

taken from a list of standard tariffs

based on a contract for multiple transports

based on negotiations for this specific transport

Don’t know

other, that is: ____

ASK ALL

SINGLE CODE

B29. How often per week does a transport of the PRODUCT take place from ORIGIN to DESTINATION?

5 or more times a week

3 to 4 times a week

1 to 2 times a week

Less than once a week

It was a one-off transport

ASK ALL

OPEN RESPONSE

ASK ALL

MULTIPLE CODE

B31. How is the load of this product treated/packed?

in boxes/packages/pallets

as dry/wet bulk

as temperature controlled transport

containers

other, namely: ________________________________

PART C: YOUR PREFERENCE

At the start of your journey, you expected the journey time from ORIGIN to DESTINATION to be ___ hours and ___ minutes [=TRANSPORT TIME]. The cost was COSTS pounds.

Below we present two Scenarios in which we change the journey time and cost.

Scenario A	**Scenario B**
transport time **… hours … minutes** *Transport costs:* **£ … . …**	*transport time:* **… hours … minutes** *Transport costs:* **£ … . …**

Transport A:

Transport time = TRANSPORT TIME

Transport costs = COSTS

Transport B:

Transport time = TRANSPORT TIME – 10%

Transport costs = COSTS + 5%

On the following screens we show you each time two alternatives that are a combination of different time and costs of freight transport.

You will see that both alternatives differ on the following properties:

The usual journey time, for example because one journey uses a shorter route or has less delay

The transport costs, because one alternative has lower fuel costs.

[new screen]

[REPEAT THE EXAMPLE OF THE PREVIOUS SCREEN]

Please imagine the following:

both journeys are **feasible** (even if they seem unrealistic)

all **other circumstances** (that are not mentioned explicitly) **are identical to those of the journey in Part B of the questionnaire that you have just completed** (for example the time or time window that the delivery should arrive)

the journeys are **equal in all respects** other than those specified (for example, that the journeys are equally safe, etc.)

the possibilities that you will see for time, costs, etc. **are not only available for your company**, but for all companies that use the same infrastructure. This is an important starting point in making the choices below.

[new screen]

(CARRIER and Shipper (B) and Shipper (C))

If in some alternative the journey time would be shorter than it currently is, then you could possibly use this time gain to employ the vehicle and driver elsewhere in a productive way (and with longer times you possibly have additional costs for the vehicle and personnel).

(CARRIER)

For your choices you do **not** have to consider what would happen with the transported products when journey time would increase or decrease (perishing, postponement of a production process, running out of stock). These are questions we ask the shippers.

(SHIPPER (A) and SHIPPER (B) and SHIPPER (C))

For your choices, take into account what would happen to the transported products when journey time would increase or decrease (perishing, postponement of a production process, running out of stock).

(SHIPPER (A))

For your choices you do **not** have to consider that a longer journey time can lead to extra costs for personnel or vehicles. These questions are asked to the carriers.

ASK ALL

C1. Which scenario do you prefer? (1 of 8)

Scenario A	**Scenario B**
transport time **… hours … minutes**	*transport time:* **… hours … minutes**
Transport costs: **£ … . …**	*Transport costs:* **£ … . …**

I prefer Scenario A ☐ I prefer Scenario B

C2. Which scenario do you prefer? (2 of 8)

Scenario A	Scenario B
transport time **… hours … minutes** *Transport costs:* **£ … . …**	*transport time:* **… hours … minutes** *Transport costs:* **£ … . …**

I prefer Scenario A ☐ I prefer Scenario B

C3. Which scenario do you prefer? (3 of 8)

Scenario A	Scenario B
transport time **… hours … minutes** *Transport costs:* **£ … . …**	*transport time:* **… hours … minutes** *Transport costs:* **£ … . …**

I prefer Scenario A ☐ I prefer Scenario B

C4. Which Scenario do you prefer? (4 of 8)

Scenario A	Scenario B
transport time **… hours … minutes** *Transport costs:* **£ … . …**	*transport time:* **… hours … minutes** *Transport costs:* **£ … . …**

I prefer Scenario A ☐ I prefer Scenario B

C5. Which Scenario do you prefer? (5 of 8)

Scenario A	Scenario B
transport time **… hours … minutes** *Transport costs:* **£ … . …**	*transport time:* **… hours … minutes** *Transport costs:* **£ … . …**

I prefer Scenario A ☐ I prefer Scenario B

C6. Which Scenario do you prefer? (6 of 8)

Scenario A	Scenario B
transport time **… hours … minutes** *Transport costs:* **£ … . …**	*transport time:* **… hours … minutes** *Transport costs:* **£ … . …**

I prefer Scenario A ☐ I prefer Scenario B

C7. Which Scenario do you prefer? (6 of 8)

Scenario A	Scenario B
transport time **… hours … minutes** *Transport costs:* **£ … . …**	*transport time:* **… hours … minutes** *Transport costs:* **£ … . …**

I prefer Scenario A ☐ I prefer Scenario B

C8. Which Scenario do you prefer? (6 of 8)

Scenario A	Scenario B
transport time **… hours … minutes** *Transport costs:* **£ … . …**	*transport time:* **… hours … minutes** *Transport costs:* **£ … . …**

I prefer Scenario A ☐ I prefer Scenario B

C9. Which Scenario do you prefer? (7 of 8)

Scenario A	Scenario B
transport time **… hours … minutes** *Transport costs:* **£ … . …**	*transport time:* **… hours … minutes** *Transport costs:* **£ … . …**

I prefer Scenario A ☐ I prefer Scenario B

C10. Which Scenario do you prefer? (8 of 8)

Scenario A

transport time
… hours … minutes

Transport costs:
£ … . …

Scenario B

transport time:
… hours … minutes

Transport costs:
£ … . …

I prefer Scenario A ☐ I prefer Scenario B

PART D: UNCERTAIN JOURNEY TIMES

(SAME FOR CARRIER, SHIPPER…)

We now add uncertainty to the journey times.

Unexpected delays can occur, for example, due to:

roadworks

unexpected traffic

weather conditions

but the journey time can also be shorter than expected because traffic was not too bad.

We represent this uncertainty with **5 possible journey times for the same journey.**

Scenario A

Each of the five transport times has the same probability to occur

Transport time:

1. **..hrs ..m**
2. **..hrs ..m**
3. **..hrs ..m**
4. **..hrs ..m**
5. **..hrs ..m**

Average transport time:
… hours … minutes

Transport costs:
£ … . …

Scenario A:

Average transport time: TRANSPORT TIME

Transport costs: COSTS

1: TRANSPORT TIME + 10%

2: TRANSPORT TIME

3: TRANSPORT TIME

4: TRANSPORT TIME – 20%

5: TRANSPORT TIME – 40%

[new screen]

[REPEAT THE EXAMPLE OF THE PREVIOUS SCREEN]

ASK ALL

SINGLE CODE

D1. How often do you take the possibility of uncertainty in journey times into account?

never

sometimes

usually

(almost) always

ASK ALL

MULTIPLE CODE

D2. How do you take this into account?

I shift the departure time

I take another route

I choose another means of transport

Other, namely ______

[new screen]

[REPEAT THE EXAMPLE OF THE PREVIOUS SCREEN]

(ASK CARRIER AND SHIPPER (B) AND SHIPPER (C) ONLY)

Please imagine that you are about to perform the journey:

the **departure time** is **fixed**

the **journey time** is **uncertain,** so arrival time is uncertain too

you know that one of the 5 possible journey times will be the true journey time, but you do not know which one it will be.

Do consider what happens to the staff and vehicles

(ASK CARRIER ONLY)

You do **not** have to consider what would happen with the transported products when journey time would increase or decrease (perishing, postponement of a production process, running out of stock). These are questions we ask the shippers.

(SHIPPER (A) Please imagine that you are about to perform the journey:

the **departure time** is **fixed**

the **journey time** is **uncertain,** so arrival time is uncertain too

you know that one of the 5 possible journey times will be the true journey time, but you do not know which one it will be

Do not consider what would happen to the staff or vehicles. These are questions we ask the carriers.

(SHIPPER (A) AND SHIPPER (B) AND SHIPPER (C) ONLY)

Do consider what would happen to the goods

SHOWN TO ALL

As with throwing dice, in the long run you should expect to see each side equally often. So, when making the journey often enough, you would experience every journey time equally often. But of course, a certain side may show up two times in succession, and there is no guarantee that a side that hasn't appeared for a while will show up the next time.

[new screen]

ASK ALL

D3. Which Scenario do you prefer? (1 of 9)

Scenario A

Each of the five transport times has the same probability to occur

2 hours and 10 minutes

2 hours and 40 minutes

2 hours and 40 minutes

2 hours and 40 minutes

Average Transport time:
2 hours and 40 minutes

Transport costs:
£715

Scenario B

Each of the five transport times has the same probability to occur

3 hours and 10 minutes

3 hours and 40 minutes

3 hours and 40 minutes

3 hours and 40 minutes

Average Transport time:
3 hours and 40 minutes

Transport costs:
£635

I prefer Scenario A □ I prefer Scenario B

D4. Which Scenario do you prefer? (2 of 9)

Scenario A

Each of the five transport times has the same probability to occur

2 hours and 10 minutes

2 hours and 40 minutes

2 hours and 40 minutes

2 hours and 40 minutes

Average Transport time:
2 hours and 40 minutes

Transport costs:
£715

Scenario B

Each of the five transport times has the same probability to occur

3 hours and 10 minutes

3 hours and 40 minutes

3 hours and 40 minutes

3 hours and 40 minutes

Average Transport time:
3 hours and 40 minutes

Transport costs:
£ 635

I prefer Scenario A ☐ I prefer Scenario B

D5. Which Scenario do you prefer? (3 of 9)

Scenario A

Each of the five transport times has the same probability to occur

2 hours and 10 minutes

2 hours and 40 minutes

2 hours and 40 minutes

2 hours and 40 minutes

Average Transport time:
2 hours and 40 minutes

Transport costs:
£715

Scenario B

Each of the five transport times has the same probability to occur

3 hours and 10 minutes

3 hours and 40 minutes

3 hours and 40 minutes

3 hours and 40 minutes

Average Transport time:
3 hours and 40 minutes

Transport costs:
£ 635

I prefer Scenario A ☐ I prefer Scenario B

D6. Which Scenario do you prefer? (4 of 9)

Scenario A

Each of the five transport times has the same probability to occur

2 hours and 10 minutes

2 hours and 40 minutes

2 hours and 40 minutes

2 hours and 40 minutes

Average Transport time:
2 hours and 40 minutes

Transport costs:
£715

Scenario B

Each of the five transport times has the same probability to occur

3 hours and 10 minutes

3 hours and 40 minutes

3 hours and 40 minutes

3 hours and 40 minutes

Average Transport time:
3 hours and 40 minutes

Transport costs:
£ 635

I prefer Scenario A ☐ I prefer Scenario B

D7. Which Scenario do you prefer? (5 of 9)

Scenario A

Each of the five transport times has the same probability to occur

2 hours and 10 minutes

2 hours and 40 minutes

2 hours and 40 minutes

2 hours and 40 minutes

Average Transport time:
2 hours and 40 minutes

Transport costs:
£715

Scenario B

Each of the five transport times has the same probability to occur

3 hours and 10 minutes

3 hours and 40 minutes

3 hours and 40 minutes

3 hours and 40 minutes

Average Transport time:
3 hours and 40 minutes

Transport costs:
£ 635

I prefer Scenario A ☐ I prefer Scenario B

D8. Which Scenario do you prefer? (6 of 9)

Scenario A

Each of the five transport times has the same probability to occur

2 hours and 10 minutes

2 hours and 40 minutes

2 hours and 40 minutes

2 hours and 40 minutes

Average Transport time:
2 hours and 40 minutes

Transport costs:
£715

Scenario B

Each of the five transport times has the same probability to occur

3 hours and 10 minutes

3 hours and 40 minutes

3 hours and 40 minutes

3 hours and 40 minutes

Average Transport time:
3 hours and 40 minutes

Transport costs:
£ 635

I prefer Scenario A ☐ I prefer Scenario B

D9. Which Scenario do you prefer? (7 of 9)

Scenario A

Each of the five transport times has the same probability to occur

2 hours and 10 minutes

2 hours and 40 minutes

2 hours and 40 minutes

2 hours and 40 minutes

Average Transport time:
2 hours and 40 minutes

Transport costs:
£715

Scenario B

Each of the five transport times has the same probability to occur

3 hours and 10 minutes

3 hours and 40 minutes

3 hours and 40 minutes

3 hours and 40 minutes

Average Transport time:
3 hours and 40 minutes

Transport costs:
£ 635

I prefer Scenario A ☐ I prefer Scenario B

D10. Which Scenario do you prefer? (8 of 9)

Scenario A	Scenario B
Each of the five transport times has the same probability to occur	Each of the five transport times has the same probability to occur
2 hours and 10 minutes	3 hours and 10 minutes
2 hours and 40 minutes	3 hours and 40 minutes
2 hours and 40 minutes	3 hours and 40 minutes
2 hours and 40 minutes	3 hours and 40 minutes
Average Transport time: **2 hours and 40 minutes**	*Average Transport time:* **3 hours and 40 minutes**
Transport costs: **£715**	*Transport costs:* **£ 635**

I prefer Scenario A □ I prefer Scenario B

D11. Which Scenario do you prefer? (9 of 9)

Scenario A	Scenario B
Each of the five transport times has the same probability to occur	Each of the five transport times has the same probability to occur
2 hours and 10 minutes	3 hours and 10 minutes
2 hours and 40 minutes	3 hours and 40 minutes
2 hours and 40 minutes	3 hours and 40 minutes
2 hours and 40 minutes	3 hours and 40 minutes
Average Transport time: **2 hours and 40 minutes**	*Average Transport time:* **3 hours and 40 minutes**
Transport costs: **£715**	*Transport costs:* **£ 635**

I prefer Scenario A □ I prefer Scenario B

ASK ALL

SINGLE CODE

D12. You have now answered 17 choice questions in total. Did you feel that you were always able to make a sensible choice between the journeys?

yes

no, because ____

ASK ALL

SINGLE CODE

D13. Did you find the description of the journeys clear?

yes

no, because ____

ASK ALL

MULTIPLE CODE

D14. Did you think the journeys were realistic?

yes

no, the presented travel times were too high or too low

No, the variation in travel times was too high or too low

No, the presented travel costs were too high or too low

because ____

ASK ALL

OPEN RESPONSE

D15: Remarks:

____

D17. Finally, would you be willing to be contacted in the future for any further research in relation to this project?

Yes

No

Thank you for your cooperation

A.3 Results from exclusion criteria

This Appendix describes the results associated with cleaning criteria C1-C5 presented in Section 5. As a point of reference, the preliminary analyses covers the estimation of Random Utility Maximisation models in willingness-to-pay space using additive error terms. Details on the model structures are included in Appendix A.1 and Appendix A.4. Separate models were estimated for shippers and carriers and discussed accordingly below. The only parameters included in these models are listed below and their interpretation is consistent with those used in the main report:

- An alternative specific constant (ASC) for the left alternative capturing potential left/right bias in choice behaviour.
- A direct estimate for the Value of Transport Time (base: OGV1 trips not to port).
- Interaction variables (multipliers) for reliability, vehicle type (LGV, OGV1 and OGV2) and destinations to/from port.
- Scale parameter accounting for differences in the variance between SP1 and SP2.

For shippers, Table 63 reports the VTT and VTTR estimates for the full sample and C1-C4. Depending on the implemented exclusion criterion the VTT and VTTR estimates adjust due to variations in the sample considered. A full description of the number of respondents excluded by segment is presented in the main report. With some exceptions in place, the VTT and VTTR estimates increase slightly when implementing C1-C3. Only when C4 is implemented a drop in the VTT and VTTR estimates is observed, but this is combined with a large loss in sample size. The variation in the VTT and VTTR is smaller for carriers when implementing C1-C3, and the VTT again decreases when implementing C4, but again at the expense of a large loss in sample size (see

Table 64).

Table 63: Impact of the exclusion criteria on the VTT and VTTR (£ per hr) estimates for shippers

	Shippers				
	Full sample	C1	C2	C3	C4
Observations	205	190	182	179	130
Observations removed		15	23	26	75
VTT (£ per hr)					
LGV not to port	£ 148.76	£ 182.82	£ 175.53	£ 177.49	£ 127.23
LGV to port	£ 208.44	£ 224.88	£ 293.05	£ 290.39	£ 179.55
OGV1 not to port	£ 86.07	£ 96.24	£ 86.18	£ 86.00	£ 85.33
OGV1 to port	£ 120.60	£ 118.39	£ 143.88	£ 140.70	£ 120.42
OGV2 not to port	£ 70.73	£ 76.98	£ 63.55	£ 64.40	£ 78.09
OGV2 to port	£ 99.11	£ 94.69	£ 106.10	£ 105.37	£ 110.21
VTTR (£ per hr)					
LGV not to port	£ 28.85	£ 35.45	£ 34.04	£ 34.42	£ 24.67
LGV to port	£ 40.42	£ 37.54	£ 65.37	£ 67.00	£ 31.78
OGV1 not to port	£ 16.69	£ 16.07	£ 19.22	£ 19.84	£ 15.10
OGV1 to port	£ 23.39	£ 19.76	£ 32.10	£ 32.47	£ 21.31
OGV2 not to port	£ 13.72	£ 12.85	£ 14.18	£ 14.86	£ 13.82
OGV2 to port	£ 19.22	£ 15.81	£ 23.67	£ 24.31	£ 19.51

Table 64: Impact of the exclusion criteria on the VTT and VTTR (£ per hr) estimates for carriers

	Carriers				
	Full sample	C1	C2	C3	C4
Observations	367	341	335	329	247
Observations removed		26	32	38	120
VTT (£ per hr)					
LGV not to port	£ 419.62	£ 399.68	£ 416.39	£ 418.35	£ 349.90
LGV to port	£ 347.45	£ 336.69	£ 346.33	£ 354.98	£ 256.67
OGV1 not to port	£ 139.80	£ 135.52	£ 142.46	£ 142.87	£ 150.90
OGV1 to port	£ 115.76	£ 114.16	£ 118.49	£ 121.23	£ 110.70
OGV2 not to port	£ 79.20	£ 73.66	£ 81.51	£ 80.23	£ 81.97
OGV2 to port	£ 65.58	£ 62.05	£ 67.80	£ 68.08	£ 60.13
VTTR (£ per hr)					
LGV not to port	£ 144.68	£ 137.80	£ 143.56	£ 144.24	£ 120.64
LGV to port	£ 119.79	£ 120.79	£ 120.16	£ 126.36	£ 67.23
OGV1 not to port	£ 48.20	£ 48.62	£ 49.43	£ 50.86	£ 39.52
OGV1 to port	£ 39.91	£ 40.96	£ 41.11	£ 43.15	£ 28.99
OGV2 not to port	£ 27.31	£ 26.43	£ 28.28	£ 28.56	£ 21.47
OGV2 to port	£ 22.61	£ 22.26	£ 23.52	£ 24.23	£ 15.75

Exclusion criterion 5 relates to the extent to which respondents accept the highest presented BVTT value. Figure 10 and Figure 11 reveal that for shippers and carriers the majority of respondent reject the highest presented BVTT value (expressed here in £ per tonne per hour), but this share is much higher for carriers than shippers (i.e. there is a spike in the histogram around £0/hr, indicating non-acceptance). However, when carriers accept the highest BVTT presented, they are accepting a BVTT which is much higher than for shippers.

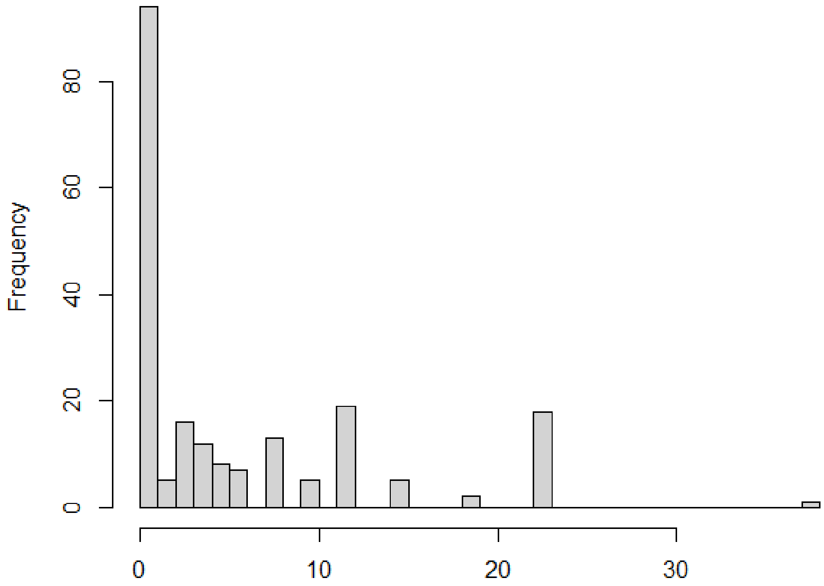


Figure 10: Histogram of highest accepted BVTT (£ per tonne per hr) for shippers

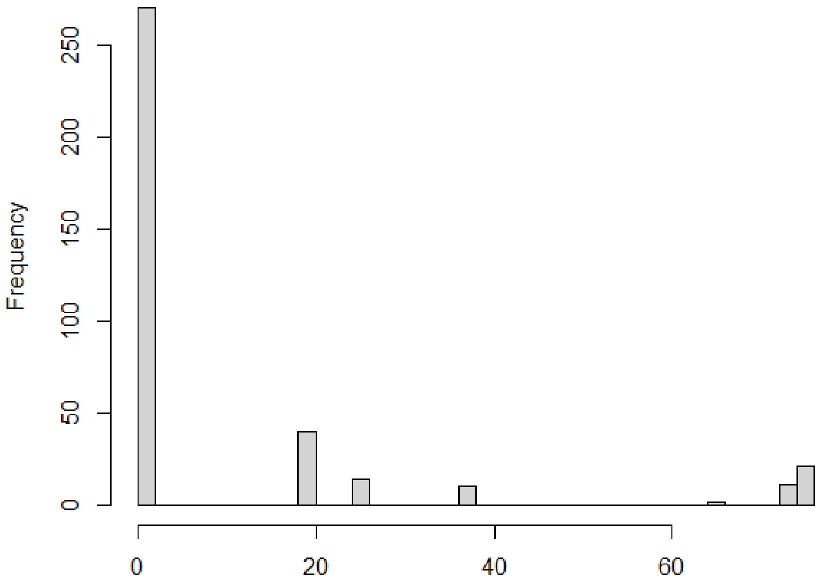


Figure 11: Histogram of highest accepted BVTT (£ per tonne per hr) for carriers

In relation to exclusion criterion C5 the impact on the VTT by removing respondents accepting a very high BVTT at different cut-off values is tested. Table 65 shows that for shippers primarily the LGV sample is affected by the cut-off values. It is only when reaching cut-off values of £10 and £5 per tonne per hour for accepting the highest presented BVTT that decreases in the VTT for the other segments. When moving beyond a cut-off value of below £15 per tonne per hour the sample size gets significantly affected and accordingly, the recommended result is that for the OGV samples no cut-off value is implemented for shippers, whereas for the LGV sample a cut-off value of £15 is implemented.

Table 65 Cut-off values for C5 (highest accepted BVTT £ per tonne per hour) on the VTT and VTTR (£ per hr) - shippers

	Full sample	C5 - £30	C5 - £15	C5- £10	C5 - £5
Observations	205	204	183	160	133
Observations removed		1	22	45	72
VTT (£ per hr)					
LGV not to port	£ 148.76	£ 148.43	£ 115.77	£ 96.95	£ 161.62
LGV to port	£ 208.44	£ 208.11	£ 169.88	£ 154.90	£ 158.03
OGV1 not to port	£ 86.07	£ 85.89	£ 82.92	£ 73.31	£ 85.89
OGV1 to port	£ 120.60	£ 120.42	£ 121.67	£ 117.13	£ 83.98
OGV2 not to port	£ 70.73	£ 70.70	£ 68.36	£ 58.10	£ 58.02
OGV2 to port	£ 99.11	£ 99.12	£ 100.31	£ 92.83	£ 56.74
VTTR (£ per hr)					
LGV not to port	£ 28.85	£ 28.79	£ 22.45	£ 18.80	£ 31.34
LGV to port	£ 40.42	£ 41.17	£ 36.92	£ 37.64	£ 93.31
OGV1 not to port	£ 16.69	£ 16.99	£ 18.02	£ 17.82	£ 50.71
OGV1 to port	£ 23.39	£ 23.82	£ 26.44	£ 28.47	£ 49.59
OGV2 not to port	£ 13.72	£ 13.98	£ 14.86	£ 14.12	£ 34.26
OGV2 to port	£ 19.22	£ 19.61	£ 21.80	£ 22.56	£ 33.50

Table 66 displays the same set of results for the carriers, but using appropriate cut-off values aligning with the patterns observed in Figure 11. The VTT and VTTR values are decreasing across all segments and the balance with the number of observations removed results in the recommendation of applying a cut-off value for £30 pounds per tonne per hour for all carrier segments.

Table 66 Cut-off values for C5 (highest accepted BVTT £ per tonne per hour) on the VTT and VTTR (£ per hr) - carriers

	Carriers			
	Full sample	C5 - £60	C5 - £30	C5- £15
Observations	367	334	324	270
Observations removed		33	43	97
VTT (£ per hr)				
LGV not to port	£ 419.62	£ 312.15	£ 262.73	£ 161.62
LGV to port	£ 347.45	£ 284.19	£ 247.94	£ 158.03
OGV1 not to port	£ 139.80	£ 113.80	£ 101.26	£ 85.89
OGV1 to port	£ 115.76	£ 103.60	£ 95.56	£ 83.98
OGV2 not to port	£ 79.20	£ 70.08	£ 63.53	£ 58.02
OGV2 to port	£ 65.58	£ 63.80	£ 59.95	£ 56.74
VTTR (£ per hr)				
LGV not to port	£ 144.68	£ 107.62	£ 90.58	£ 55.72
LGV to port	£ 119.79	£ 126.42	£ 125.52	£ 93.31
OGV1 not to port	£ 48.20	£ 50.62	£ 51.27	£ 50.71
OGV1 to port	£ 39.91	£ 46.09	£ 48.38	£ 49.59
OGV2 not to port	£ 27.31	£ 31.18	£ 32.16	£ 34.26
OGV2 to port	£ 22.61	£ 28.38	£ 30.35	£ 33.50

A.4 Functional forms used in the discrete choice models

Section 5 of the main report discusses the selection of the functional form, the treatment of the error terms and the treatment of observed and unobserved heterogeneity. This Appendix provides more technical insights into the six functional forms applied.

Functional form and treatment of error terms

1. *Random utility maximisation (RUM) in WTP space with additive error terms*

The specification for the RUM model with additive errors is consistent with that presented in the main report

$$V_{jnt} = \mu_{nt} \cdot \left(ASC_j - VTT_n \cdot TT_{jnt} - VTTR_n \cdot SD_{jnt} - TC_{jnt}\right) + \epsilon_{jnt}$$

Where:

- *j*, *n*, and *t* represent subscripts relating to the alternative (Scenario A and B), respondent and choice task, respectively.
- ASC_j denotes an alternative specific constant for alternative *j* – possibly accounting for left/right biases in response patterns. For identification purposes one of the ASCs needs to be normalised to zero.
- VTT_n represents the marginal (dis)utility of transport time. Due to the opportunity costs of transport time this coefficient is expected to be negative. The subscript *n* indicates that its value may vary across respondents using both observed and unobserved heterogeneity, which is discussed in more detail below.
- TT_{jnt} captures the transport time in minutes associated with alternative *j*
- $VTTR_n$ represents the marginal (dis)utility of the standard deviation of transport time. Due to the uncertainty introduced by unreliable travel times this coefficient is expected to be negative.
- SD_{jnt} captures the standard deviation of travel time (in minutes) of alternative *j*
- TC_{jnt} captures the travel costs in GBP associated with alternative *j*
- μ_{nt} represents the scale parameter of the logit model and is perfectly confounded with the negative of the cost coefficient β_{TC}. The two aspects cannot be separated.
- ϵ_{jnt} represents an error term following an extreme value Type 1 distribution such that binary logit type choice probabilities emerge.

2. *Random utility maximisation (RUM) in WTP space with multiplicative error terms*

The multiplicative error specification takes the following form $V_j = f(X, \beta) \cdot \epsilon_j$ for all three potential model forms (RUM, random valuation (RV) and relative models). When implementing the multiplicative error terms the natural log is applied to bring estimation back in the realm of the traditional binary logit model, such that:

$$V^*_{jnt} = \ln\left(f\left(X_{jnt}, \beta\right)\right) + \epsilon^*_{jnt}$$

Where ϵ^*_j takes the traditional form of a Type I extreme value distribution. For the natural logarithm to work $f\left(X_{jnt}, \beta\right)$ needs to be positive. For the RUM model in WTP space this results in the following specification:

$$V^*_{jnt} = -\mu_{nt} \cdot \ln\left(-ASC_j + VTT_n \cdot TT_{jnt} + VTTR_n \cdot SD_{jnt} + TC_{jnt}\right) + \epsilon^*_{jnt}$$

The negative sign in front of the scale parameter μ_{nt} ensures that increases in travel cost (TC_{jnt}) are associated with reductions in V^*_{jnt}, make alternative *j* less attractive relative to other alternatives and thereby reduce its choice probability, whilst ensuring that the term inside the ln() term stays positive. The same logic applies to transport time $\left(TT_{jnt}\right)$, and the standard deviation of travel time $\left(SD_{jnt}\right)$ because the VTT and VTTR are assumed to be positive. This logarithmic transformation does not change the interpretation of the core parameters of interest. The only change is that the scale parameter is no longer perfectly confounded with the cost parameter.

3. *RV for SP1 and RUM in WTP space for SP2 with additive error terms*

The implementation of the RV model is slightly more contrived, because it only applies to SP1 whilst jointly estimating data from SP1 and SP2. Since both the RUM model in WTP space and RV models directly estimate the VTT, the two model specifications can nevertheless be combined in estimation. The functional form for this hybrid model using additive error terms becomes:

$$V_{Ant} = \exp\left(\mu^*\right) \cdot \left[\left(SP1_{nt} \cdot BVTT_{nt}\right) + SP2_{nt} \cdot \gamma_{SP2} \cdot \left(ASC_A - VTT_n \cdot TT_{Ant} - VTTR_n \cdot SD_{Ant} - TC_{Ant}\right)\right] + \epsilon_{Ant}$$

$$V_{Bnt} = \exp\left(\mu^*\right) \cdot \left[\left(SP1_{nt} \cdot VTT_n\right) + SP2_{nt} \cdot \gamma_{SP2} \cdot \left(ASC_B - VTT_n \cdot TT_{Bnt} - VTTR_n \cdot SD_{Bnt} - TC_{Bnt}\right)\right] + \epsilon_{Bnt}$$

Essential is that the choices have been recoded such that a choice for the cheap but slow option in SP1 corresponds to a choice for alternative A (i.e. the left alternative), and that a choice for the fast but expensive option in SP1 corresponds to a choice for alternative B (i.e. the right alternative). In the above, μ^* refers to the scale for SP1 (and the RV model), $SP1_{nt}$ and $SP2_{nt}$are dummy variables identifying if a given choice corresponds to SP1 or SP2. If the choice corresponds to SP1, the BVTT vs VTT specification as introduced in the main text of the report is introduced, whereas if the choice corresponds to SP2 the RUM in WTP space, the specification for RUM in WTP space is introduced. Note that $\gamma_{SP2}$is an additional scale parameter capturing scale differences between SP1 and SP2.

4. *RV for SP1 and RUM in WTP space for SP2 with multiplicative error terms*

The transformation from additive error terms to multiplicative error terms is similar as for the RUM models. Note that in the below the natural logarithm is taken for both sub components, but that the change of signs are only needed for the SP2 part since the BVTT and the VTT are expected to be positive in SP1.

$$\begin{aligned} V_{Ant}^* = \exp\left(\mu^*\right) & \\ & \cdot \left[\left(SP1_{nt} \cdot \ln\left(BVTT_{nt}\right)\right) - SP2_{nt} \cdot \gamma_{SP2} \right. \\ & \left. \cdot\, ln\left(-ASC_A + VTT_n \cdot TT_{Ant} + VTTR_n \cdot SD_{Ant} + TC_{Ant}\right)\right] + \epsilon_{Ant}^* \end{aligned}$$

$$\begin{aligned} V_{Bnt} = \exp\left(\mu^*\right) & \\ & \cdot \left[\left(SP1_{nt} \cdot \ln\left(VTT_n\right)\right) - SP2_{nt} \cdot \gamma_{SP2} \right. \\ & \left. \cdot\, ln\left(-ASC_B + VTT_n \cdot TT_{Bnt} + VTTR_n \cdot SD_{Bnt} + TC_{Bnt}\right)\right] + \epsilon_{Bnt}^* \end{aligned}$$

5. *Relative models with additive and multiplicative error terms*

The model specifications for the relative models are very comparable to those for the RUM model. In it's additive form the utility function is given by:

$$V_{jnt} = ASC_j + \beta_{TC}^{rel} \cdot \frac{TC_{jnt}}{TC_n^{base}} + \beta_{TC}^{rel} \cdot \frac{TT_{jnt}}{TT_n^{base}} + \beta_{TC}^{rel} \cdot \frac{SD_{jnt}}{SD^{base}} + \epsilon_{jnt}$$

The only differences from the RUM model emerge due to the scaling of the explanatory variables by the reference values from the typical transport, and the estimation of a parameter for the transport costs, such that the scale parameter is no longer estimated.

In its multiplicative form the utility function is given by:

$$V_{jnt}^* = -\mu_{nt} \cdot \ln\left(-ASC_j - \beta_{TC}^{rel} \cdot \frac{TC_{jnt}}{TC_n^{base}} - \beta_{TC}^{rel} \cdot \frac{TT_{jnt}}{TT_n^{base}} - \beta_{TC}^{rel} \cdot \frac{SD_{jnt}}{SD^{base}}\right) + \epsilon_{jnt}^*$$

Where the same change of signs occurs as for the RUM model in WTP space with multiplicative error terms.

Three further issues deserve some more detailed discussion, namely the scale parameter and the treatment of observed and unobserved heterogeneity in the model specifications.

The scale parameter

The scale parameter μ_{nt} needs to be positive by default and hence take the basic form $\mu_{nt} = e^{\mu^*}$. To allow for scale differences between SP1 and SP2, due to inclusion of additional attributes, the following functional form is estimated $\mu_{nt} = e^{\mu^*} \cdot \lambda_{SP2} \cdot (1 - SP2_{nt})$, where the variable $SP2_{nt}$ takes the value 1 if the choice task is in SP2 and 0 otherwise, such that e^{μ^*} refers to the scale of SP1. This functional form can easily be extended to account for more variations in the scale parameter.

Observed heterogeneity in the VTT

The VTT_n parameter varies across respondents using observed and unobserved heterogeneity. Observed heterogeneity relates to interacting VTT_n with variables in the database believed to influence the VTT. These variables can relate to the characteristics of the firm and the characteristics of the typical transport, including the vehicle characteristics and the goods transported. For example, when multiplying the base VTT parameter θ – which here relates to OGV1 transports - with $\gamma_{OGV2}^{\delta OGV_2}$, where γ_{OGV2} is a parameter to be estimated and δ_{OGV_2} is a dummy variable which takes the value 1 if the transport is made by OGV2 and 0 if it is made by OGV1, the VTT for OGV2 trips is equivalent to $VTT_{OGV2} = \theta \cdot \gamma_{OGV2}$. A value for γ_{OGV2} larger than 1 will indicate that the VTT for OGV2 is higher than for OGV1.

A range of different dummy variables z are included in the final models to see if they influence the VTT, including the different commodity types transported. This results in the following specification:

$$VTT_n = \theta \cdot \prod_{z=1}^{Z} \gamma_z^{\delta_{zn}}$$

This multiplicative treatment of interaction effects is consistent with the UK passenger VTT study and significantly reduces the potential combinations of parameters to be estimated when looking at combinations of traditional additive interaction variables (Hess et al. 2017).

In addition to dummy variables, elasticities of the VTT are estimated related to the distance, time and cost of the typical transport. This expands the functional form for VTT_n to:

$$VTT_n = \theta \cdot \prod_{z=1}^{Z} \gamma_z^{\delta_{zn}} \cdot \prod_{k=1}^{K} q_{kn}^{\omega_k}$$

In the above, k refers to the continuous variables for time, cost and distance for the typical transport. The absolute value for these variables, q_{kn}^* is divided by its mean value $\overline{q_k}$ to ensure θ refers to the VTT of a base shipment (e.g. OGV1) over the average time, cost and distance. In other words, $q_{kn} = \frac{q_{kn}^*}{\bar{q}}$. This transformation does not influence the interpretation of the corresponding parameter ω_k which represents the elasticity of the VTT with respect to q_k. Accordingly, ω_k reflects the percentage increase in the VTT as, for example, the transport costs increase by 1 percent.

Finally, the VTTR is treated as a multiplier of the VTT such that $VTTR_n = VTT_n \cdot \gamma_{VTTR}$. By default, this assumption implies that variations in the VTT also influence the VTTR.

Unobserved heterogeneity in the VTT

Any further variations in the VTT are treated as unobserved heterogeneity. Consistent with the 2014/15 UK passenger VTT study this is implemented by treating θ as a random parameter which is allowed to vary across respondents but not across choice tasks. Estimating random parameter, or panel mixed logit, models is common practice in the choice modelling and VTT literature (e.g. Train 2009). The choice of the mixing density explored within this study is between the lognormal and loguniform density to ensure that the θ_n, the base VTT parameter which is now allowed to vary across respondents remains positive by default. The loguniform density has the advantage over the lognormal density that it does not suffer from a very long tail of the VTT distribution as its counterpart (Hess et al. 2017). The mixed logit models make use of 1,000

Halton draws (Train et al. 2009) to simulate the log-likelihood function, which is sufficient due to the inclusion of a single random variable.