SILVERTOWN TUNNEL

Silvertown Modelling – Model Responsiveness

December 2016

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Contents

1. SUMMARY OF KEY POINTS

1.1.1 The key points arising from the analysis presented below are:

- The approach taken to assessing the impact of the charge is robust and based on the best available evidence. Given the congestion in the study area and the alternative routes, modelling the charge as an implicit part of route choice is an appropriate and sound approach. The approach is also in line with WebTAG guidance.
- The values of time used in the model:
  - have been agreed as appropriate by the independent auditor;
  - are consistent with all TfL's models since 2008 following expert advice on this issue including specifically on the Silvertown suite of models;
  - are used in the base model which validates well overall and in particular at the tolled Dartford Crossing. They also do not vary between the Reference and Assessed Case models;
  - are inline with WebTAG advice which says that 'it is better if the values of time can be retained in the base year assignment without amendment and they are changed in forecasting in line with the advice in that unit' (M3.1, p17, 2.10.16);
  - have been segmented by income in accordance with WebTAG advice on schemes that involve charging. The model reflects at a strategic level variations in income across the sub-region; and
  - have been checked against and are in line with local Stated Preference (SP) surveys; sensitivity tests at a higher value of time have been run to demonstrate that the scheme can still achieve its objectives under this scenario.
- The Assessed Case model produces results for different income groups and users that are intuitive and plausible. Further, the Base, Reference Case and Assessed Case models have been independently audited and determined fit for purpose.
- Modelled elasticities of demand and travel distance with respect to changes in fuel cost, journey time and public transport fare changes were in line with WebTAG guideline values.

- The outturn charging response has been compared to international studies of charge responses and the model's response is in line with the benchmark range from these studies.
- Considering all of the evidence that is available, the model's response to the user charge is considered to be robust. Further assurance is gained from sensitivity tests with higher values of time which demonstrate that the user charge is effective in demand managing the flow changes arising from the scheme.

2. INTRODUCTION

2.1.1 The transport models being used to assess the strategic impacts of the Silvertown Tunnel are the London Regional Demand Model (LoRDM), the River Crossings Highway Assignment Model (RXHAM) and the public transport assignment model (Railplan). These models are discussed in more detail within the response to TT1 (REP1-174) The ability of the models to represent the impacts of the proposed scheme depends on a number of different factors which together make up the model that has been agreed as fit for purpose through the audits carried out by the consultants SDG. In response to requests from the ExA, submissions made by Boroughs in Local Impact Reports and Written Representations submitted at Deadline 1 of the examination, and discussions at the Issue Specific Hearing on Traffic/Transport Modelling on 7 December 2016, this note clarifies issues around the validation of the model response to user charges.

2.1.2 This note discusses various elements of the modelling. In combination, and against the backdrop of following WebTAG guidance and subjecting the modelling to independent audit, this provides assurance that the strategic modelling is robust. This note covers the following topics:

- Background;
- Approach used to modelling user charging;
- Value of Time including benchmarking to behavioural studies (SP surveys) and income segmentation;
- Assessed case model response;
- Realism tests carried out to ensure demand elasticities associated with fuel, public transport fare and journey times were in line with WebTAG guidance; and
- Validation of the outturn response (or charge elasticity) with respect to international benchmark studies;

3. BACKGROUND

3.1.1 In terms of the context of this scheme, the options for crossing the river by motorised vehicle in East London are limited to a small number of crossings with varied physical characteristics and constraints, which are highly congested during the peak hours. Highway alternatives to the Blackwall Tunnel consist of the Rotherhithe Tunnel and Woolwich Ferry for shorter distance trips and the Dartford Crossing (which is subject to a charge) for longer distance trips. The limited options for those who need to drive across the river are demonstrated by the regular long queues currently seen at Blackwall. These queues and the associated delays can be seen as a ‘cost’ which drivers are clearly willing to pay in order to cross the river at this location. There are also public transport options available for some origins and destinations in the form of the DLR, Jubilee Line, Crossrail, other rail, Emirates Air Line and bus.

3.1.2 The scheme itself is made up of a number of components: an increase in capacity provided by a new tunnel, enhanced bus services through the new tunnel, and the introduction of a charge. By building the new tunnel, the current cost of delays will be reduced with queues being reduced and traffic being able to flow more freely. Such a cost reduction would, with all other things being equal, be expected to attract more traffic to the route, and so a charge will also be introduced, both at the Silvertown Tunnel and the existing Blackwall Tunnel, to offset the reduction in cost and manage demand. Given these components of the scheme, and reflecting the level of charge set in the Assessed Case, TfL does not expect a significant change in cross river highway journeys overall.

4. APPROACH USED TO MODEL USER CHARGING

4.1.1 The modelling of the charge response within the strategic models is made up of a number of elements. The route choice model (RXHAM) allocates travel demand (trips) from the demand model (see figure 1) for interaction between models) to routes which minimise the generalised cost of travel for users, achieving an equilibrium (end point) where no user can further reduce their generalised cost by changing route. The generalised cost measure is made of a number of components:

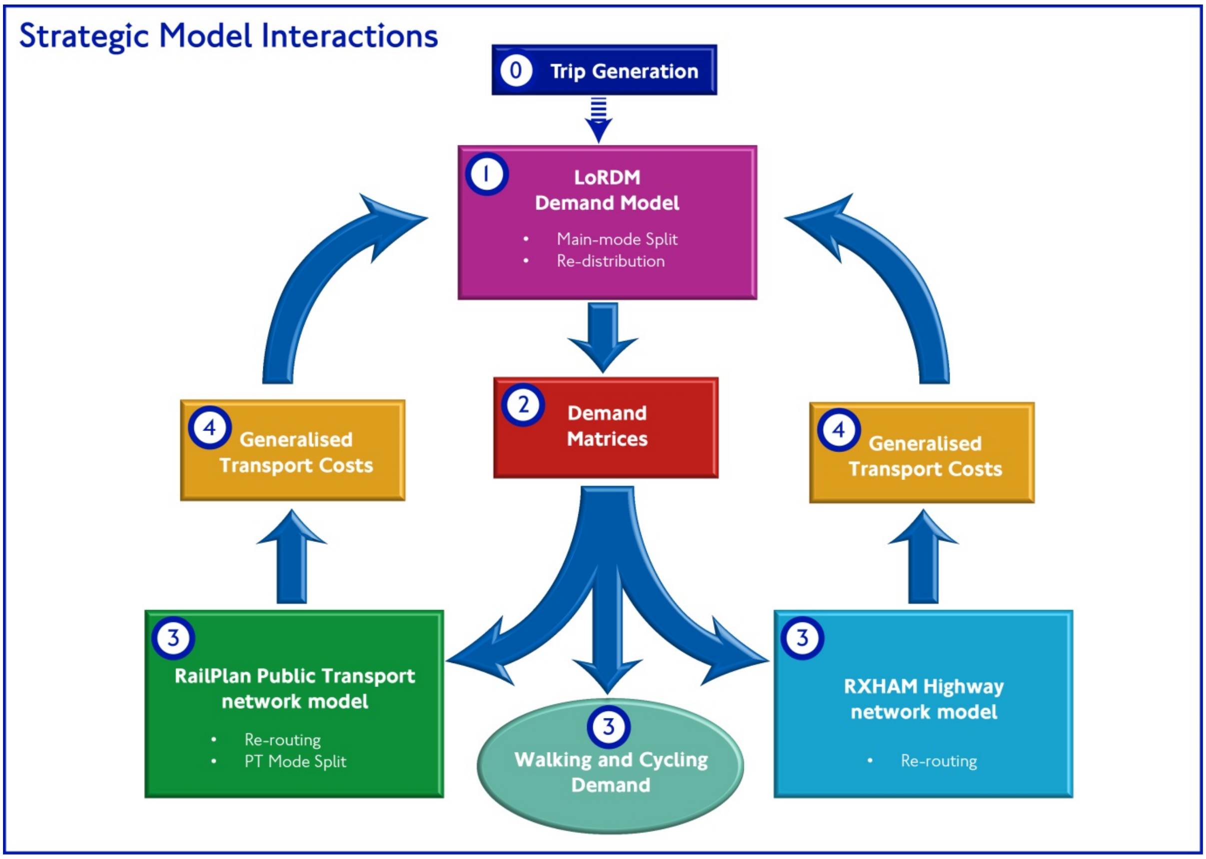
- Fuel costs
- Non-fuel vehicle operating costs
- Tolls and charges
- Journey time

4.1.2 This measure is in units of financial cost (in pence), with the time component of each route converted in to money using values of time. The value of time is the financial value (willingness to pay) placed on time savings and allows the model to trade off the time costs of different routes against financial costs outlined above (e.g. fuel) to determine the lowest generalised cost route. The values of time used in the model are discussed in more detail in Section 5, but it should be noted that they vary by journey purpose and by household income (for non-work journeys) in line with WebTAG guidance.

4.1.3 As shown in Figure 1, the generalised costs (by vehicle type and trip purpose) for each origin-destination movement (reflecting a weighted average of the costs for each route used between those location pairs) are passed to the demand model which calculates changes in trip patterns (origin destination pairs) and choice of transport mode reflecting generalised costs. Further detail is available in TT1 (REP1-174).

4.1.4 The effect of the user charge on driver behaviour is represented within the model using a method consistent with WebTAG guidance. The charge is represented as a cost applying to the use of a given link or set of links, and can vary by time and direction to reflect the charging tariff being considered at a route level. This includes Dartford Crossing in the base and Reference Case models, as well as Blackwall and Silvertown tunnels in the Assessed Case models. The model adds the charge to the other costs (e.g. time) to calculate the generalised cost of that routing.

Figure 1: Interactions within the Strategic Modelling Suite (submitted as part of TT1 - REP1-174)



4.1.5 TfL regards this as an appropriate approach in the context where the congested nature of the network means that a detailed representation of congestion effects is key to modelling the charge response effectively. The SATURN software used for the assignment stage has an ability to understand the effects of traffic blocking junctions and queuing as it incorporates junction simulation within the modelling process.

5. VALUE OF TIME ASSUMPTIONS

Background

5.1.1 One of the key inputs to modelling the charge response is the value of time i.e. the assumption about the financial value placed on time spent travelling. This value may vary depending on a number of factors such as trip purpose and income as noted above. The values of time need to be applied to all movements and not the river crossing trips alone and therefore must be appropriate for journeys that both do and do not cross the river. The Reference and Assessed cases need to use the same values – to vary between these cases would conflict with WebTAG and result in inconsistent and invalid results. It is of note that the reference case value of time has not been queried to date by either SDG or any of the Boroughs. Further, the base and reference cases both feature user charging at the Dartford Crossing and the base model validates well at this location. The count validation at Dartford is shown in table 10-4 of Appendix A in TT1 (REP1-174) and the journey time validation is presented in table 10-13 in the same document. This shows a good match to observed data in all time periods and directions. In addition the models including value of time assumptions were audited as part of the independent audit carried out by SDG.

5.1.2 A discussion note on this subject ('VOT Technical background Note.pdf' - see Appendix A) was provided to the boroughs and SDG in response to a request for further information on values of time. This analysis is expanded and updated in this section in order to provide assurance around the values chosen.

5.1.3 The Silvertown modelling uses WebTAG values of time segmented by income for non-work purposes for the base and forecast years. These values:

- Are consistent with WebTAG and advice from industry experts
- Have been segmented by income in line with WebTAG which provides a mechanism for representing differential incomes in areas of London. This reflects, for example, relatively low incomes in East Greenwich compared to West Greenwich
- Are supported by values of time obtained from local SP surveys

5.1.4 Each of the points above are discussed in more detail below.

WebTAG Guidance and Expert Advice

5.1.5 The WebTAG Forecasting & Uncertainty unit (M4, p6, 3.2.6) states that when defining the core scenario ‘The national assumptions from the TAG Data Book should not normally be varied without very strong evidence’. The TAG data book referred to here includes dataset ‘A1.3.1 - Values of Time per person’. Also in the WebTAG assignment unit (M3.1, p17, 2.10.16) ‘In the case of a highway assignment model which operates with a demand model, it is better if the values of vehicle operating cost and value of time derived from TAG unit A1.3 can be retained in the base year assignment without amendment and they are changed in forecasting in line with the advice in that unit’.

5.1.6 Further, Dr Denvil Coombe was appointed the role of independent expert advisor on river crossings modelling as well as on development of TfL’s strategic modelling capability.

5.1.7 Use of a national value is in line with his advice, with national values being used in all of TfL’s strategic modelling since 2008.

Income Segmentation

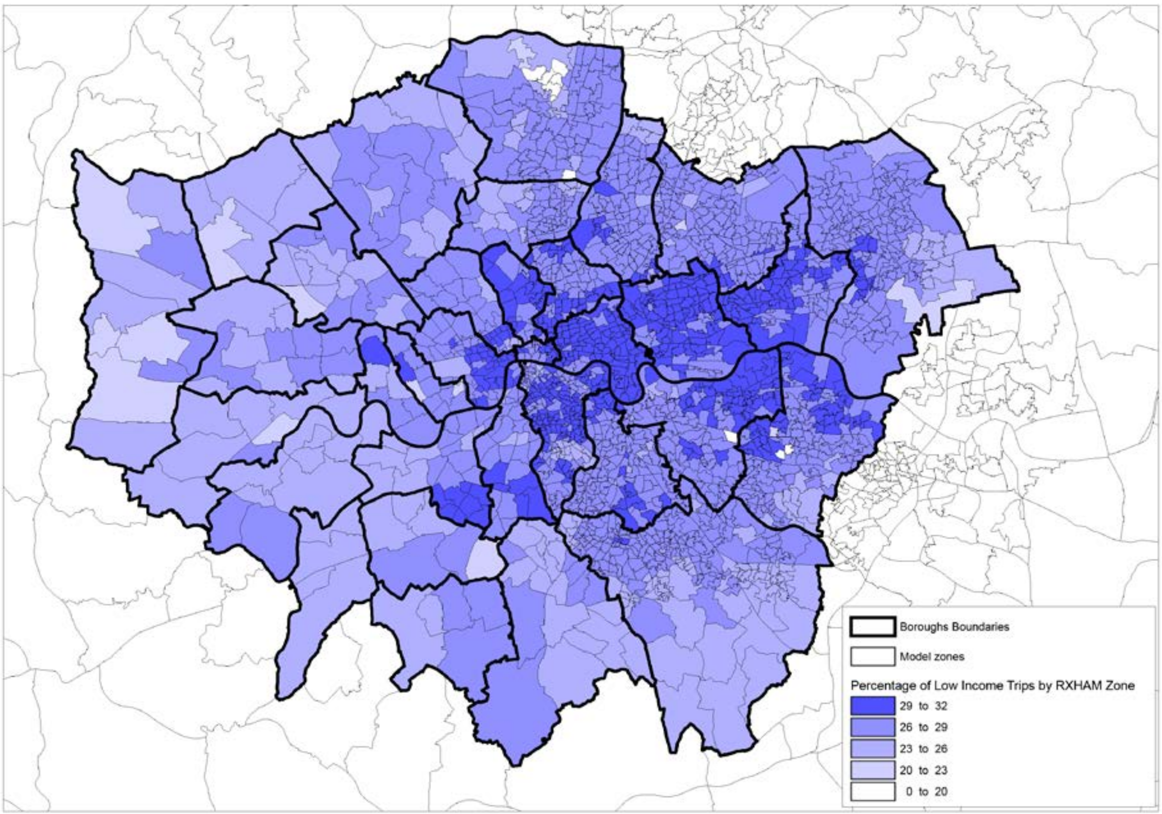
5.1.8 Where charging schemes are to be assessed, WebTAG advises that values of time are segmented by income rather than using an average value of time (TAG Unit M3.1, paragraph 2.6.2). As a result, in RXHAM car drivers are segmented into business and non-business purposes, with the latter segmented further into three income groups (as set out in the RXHAM Base Year Model Validation Report, Appendix N, Section 2.4). Each of the four car driver segments is allocated a different value of time. The non-business income groups are as follows:

- Car non-business – low income < £20,000
- Car non-business – medium income £20,000 - £50,000
- Car non-business – high income > £50,000

5.1.9 The purpose of the income segmentation is to ensure that traffic impacts reflect the differential impact of users which have differing incomes and therefore willingness to pay user charges at a strategic level.

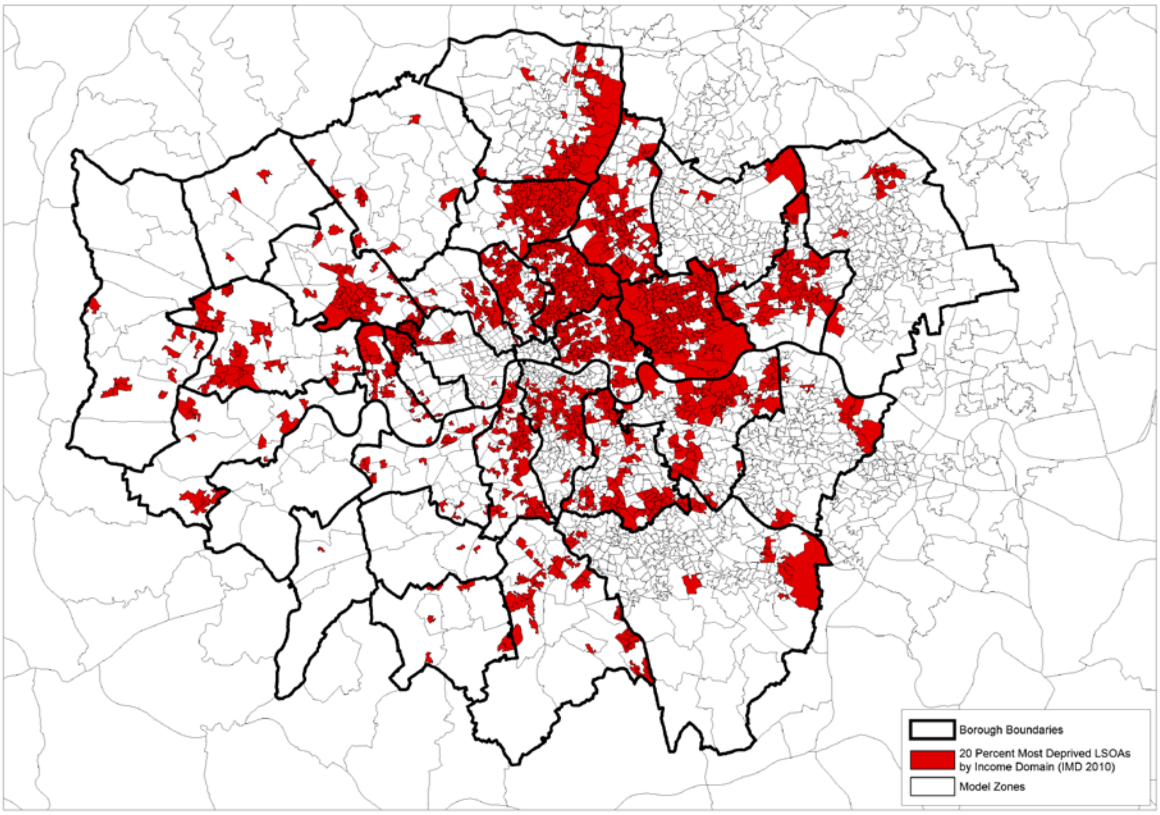
5.1.10 In order to show that the distribution of the low income user trips in the model reflects areas of deprivation and variation in income levels to the extent necessary for strategic modelling, Figure 2, below, presents AM peak origins (generally representative of the user’s home) within each income segment from the model. It shows that the income segmentation used in the model does produce varying proportions of low income household trips in different areas. In particular, it can be seen that boroughs such as Newham and Tower Hamlets have a high proportion of low income trip origins.

Figure 2: Model % of non-work (commute and other purposes) Origins corresponding with <£20K Household Income in the AM Peak (Base Year 2012)



5.1.11 This was compared to data from the income domain of the Index of Multiple Deprivation (20% most deprived households). This is shown in Figure 3 below and highlights that pockets of deprivation in Greenwich, Southwark, Newham and Tower Hamlets are represented at a strategic level. This provides further confidence in the ability of the modelling to capture differential impacts of the scheme by income segment.

Figure 3: 20% Most Deprived LSOAs (Indices of Multiple Deprivation - 2010)



Benchmarking from local SP studies

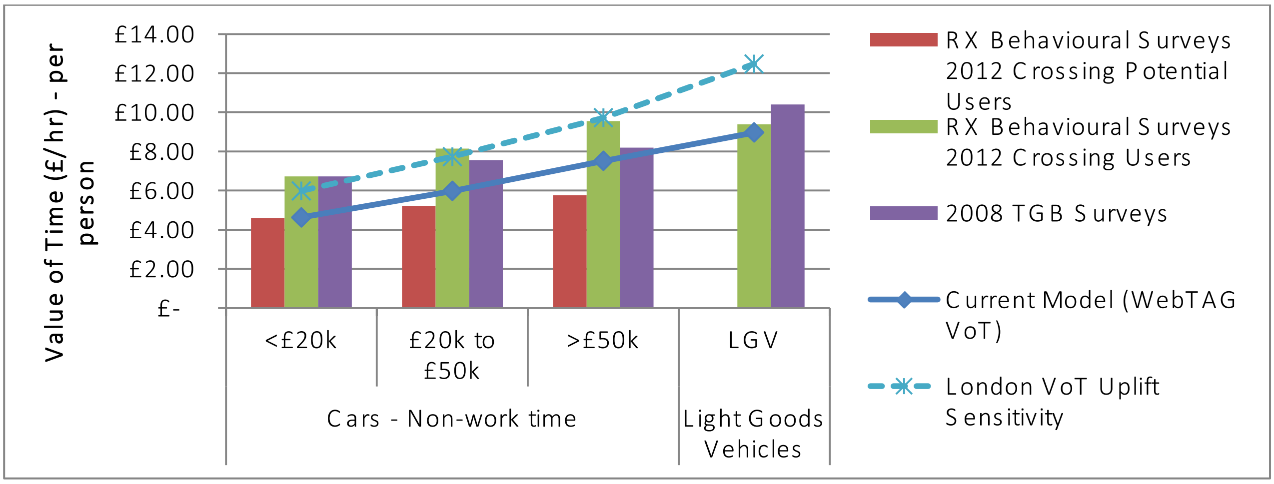
5.1.12 Behavioural data from Stated Preference (SP) surveys can be used to provide more local evidence on values of time. Two stated preference surveys for East London were carried out. The first is a specific stated preference survey and modelling exercise completed in 2008 to derive values of time for the Thames Gateway Bridge study. This provided behavioural insights which are unlikely to have significantly changed since the surveys were undertaken. The survey recruited 1,388 interviewees, with the full report provided in Appendix B. Chapter 7 notes that the corresponding values were deemed robust for crossing users but that the loss of observations (due to data cleaning steps to eliminate erroneous responses) with very low and high cost changes due to elimination of records weakens the statistical robustness of the estimates. The recommendation was therefore to use the values to support and guide model development which is indeed what was done.

5.1.13 The second SP exercise was carried out in 2012 as part of a more extensive set of behavioural studies. The primary purpose of this data collection was to gain evidence to support the development of the case for new river crossings in East London. The 'Silvertown Evidence Report' (submitted as Appendix C) contains selected findings from the behavioural surveys alongside findings from other data collection to provide my information on river crossing users.

5.1.14 The additional stated preference modelling element was used to provide local evidence to validate values of time used for transport modelling and is reported in Appendix D (note that this also contains elements already reported in Appendix C but has been sent upon request by the panel for the full documentation of surveys). The SP modelling provided values of time by income segment and trip purpose, including values for goods vehicles. The study concluded that values of time for Car Business were not sensible as values were below those for commuting and so should not be considered as suitable benchmarks for modelling. It also suggested that values for Car Commute and Other, as well as for Van/Lorry were more robust with caveats that the findings were based on a low response rate and values were those placed on time by drivers themselves and so did not reflect the effect of employers' value for the time of staff.

5.1.15 Although there are some limitations, as identified above, values of time for Out of Work Time (Commuting and Other) and LGV purposes compare well to values used in the model. All values were converted to consistent units (2012 values, 2009 prices and common purpose definition), with the comparison of values reported below in Figure 3.

Figure 4: Comparison of Model Value of Time (per person units) against benchmarks from observed studies by household income segment.



Notes:

1. Household Income definition between TGB survey and 2012 behavioural study not consistent, average value between TGB income bands used to address this (see VoT table, p60, Appendix C for unadjusted values)
2. CPI data used to standardise price year and GDP used to standardise value year.

3. 2012 surveys calculated Value of Time separately for current users of the East London River Crossings and potential users
4. 2012 behavioural survey LGV values segmented by income so middle income value used for comparison (see table 41, Appendix E for full unadjusted values)
5. London VoT calculated using TfL Business Case guidance of 29% uplift for Out of Work time purposes and 39% uplift for In Work Time Purposes (Employers Business and goods vehicles) reflecting higher London Incomes.

5.1.16 As shown by the values in figure 3, the model values of time are well supported by local surveys. There is no strong evidence to support the use of alternative values and this highlights that WebTAG values are appropriate for this study. In addition to use of the WebTAG value, sensitivity tests have been run with a higher ‘London Uplift Value of Time’. This is reported in the ‘Economic Assessment Report’ (section 5.12) and shows that scheme benefits are increased.

6. ASSESSED CASE MODEL RESPONSE

6.1.1 It is important to note the different perception of the charge that the several classes of modelled car users have, due to their varying values of time. For example, trips for business purposes are assigned a value of time that is close to twice that of the high income (household income >£50k) non-work (Commuting and Other purposes) trips. This means that the business drivers will be willing to pay twice as much for the same reduction in journey time.

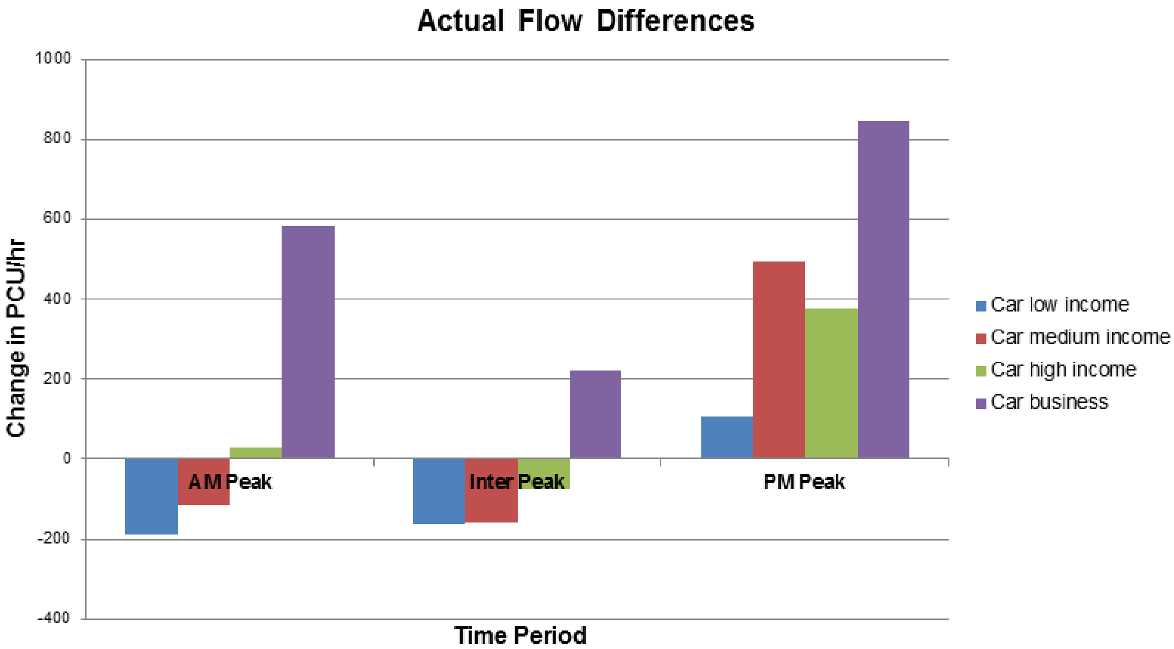
6.1.2 TfL carried out a detailed analysis of the model response for the different user classes in order to assess whether the different purpose and income user classes respond reasonably to the proposed charges. The analysis was performed by comparing the 2021 Assessed Case (S142) and 2021 Reference Case (S2) assignments. The means of assessing this response is to analyse the change in traffic flow for each class.

6.1.3 Figure 5 below summarises the modelled impact on actual flows for the different user classes using the Blackwall and Silvertown tunnels in 2021 which are modelled. This disaggregates the car user response into business and non-business, and the non-business users further by income. It shows that business user numbers increase across all time periods with non-business car travel responding differently depending on time period and level of income.

6.1.4 The response in Figure 5 also reflects that each trip purpose has a different elasticity of demand response. It should also be noted that alongside reductions in low income car user trips in some time periods and directions, there are also increases in bus use.

6.1.5 Overall, this demonstrates the ability of the model to show differential scheme impacts by user class according to journey purpose and income levels.

Figure 5: 2021 actual flow differences between the reference case and the Assessed Case – Blackwall and Silvertown tunnels combined



7. REALISM TESTS

7.1.1 WebTAG guidance requires that realism tests are carried out in order to ensure that the modelled elasticities of demand and travel distance with respect to fuel cost, journey time and public transport fare changes are in line with expected guideline values. These tests were carried out and are discussed in TT1 (LoRDM parameter Estimation section) and reported further in Appendix B of TT1 (REP1-174). In summary, they showed that modelled elasticities were in line with guidance providing further assurance of the ability of the model to provide robust modelling of the scheme impacts.

8. VALIDATION OF OUTTURN CHARGING RESPONSE (CHARGE ELASTICITIES)

8.1.1 The level of user response to a change in the level of charge is known as the charge elasticity. This is the ratio of the change in traffic flow to the change in charge. In general, it is expected that as the charge increases, increasing numbers of users will decide to choose a different route, change their trip patterns, or choose a different mode of transport. Therefore, a typical charge elasticity is negative since an increase in charge tends to lead to a decrease in flow.

8.1.2 It is important to consider that the responses to charges described above all depend in some way on the various choices available to those who are deciding whether to pay them. Most obviously, this means that outturn model charge elasticity will vary depending on the level of congestion on the charged link at the time they are considering whether to use it, as well as the level of congestion exhibited at the alternative highway river crossings and their relative suitability as alternative travel routes. This includes the attractiveness of public transport options such as cross river bus services. In general, the more alternative options are available, and the more attractive those alternatives are for the people considering whether to pay the charge, the greater the charge elasticity is likely to prove.

8.1.3 Further, the response to charging will vary by trip purpose, for example, those travelling for business will have a more inelastic demand which is reflected by a higher value of time.

8.1.4 Internationally published studies provide a number of estimates of observed charge elasticity in different contexts with relevant elasticities ranging on average from around -0.05 to -0.5. These can be used as benchmarks to assess the model response to a charge. A selection of the studies reviewed is shown in Table 1 below.

Table 1: Evidence on demand elasticity

Source	Context	Demand elasticity
London		
Evans (2008)	London's Congestion Charge zone	-0.16
Bridges and Tunnels		
Harvey (1994), cited in Matas & Raymond (2003)	Golden Gate Bridge, San Francisco Bay Bridge, and Everett Turnpike in New Hampshire (US)	Bridges: -0.05 to -0.15 Roads: -0.1
Hirschman, McNight, Paaswell, Pucher, and Berechman (1995), cited in Matas & Raymond (2003)	Six bridges and two tunnels in the New York City area (US)	-0.09 to -0.5 with an average value of -0.25
White (1984), cited in Oum et al (1992), cited in Matas & Raymond (2003)	Bridge in Southampton (UK)	Peak: -0.21 to -0.36 Off-peak: -0.14 to -0.29
Wuestefield & Regan (1981), cited in Odeck & Brathen (2008)	15 toll bridges	-0.15 to -0.31

8.1.5 A review of the outturn model elasticity was carried out using the following arc elasticity formula which calculates the percentage changes in flow and cost as an average of the before and after values:

$$E_C = \frac{\left(\frac{D_2 - D_1}{\frac{1}{2}(D_2 + D_1)}\right)}{\left(\frac{C_2 - C_1}{\frac{1}{2}(C_2 + C_1)}\right)}$$

where:

E_C = Elasticity
C_1 = original cost
C_2 = final cost
D_1 = original flow
D_2 = final flow

8.1.6 The model scenarios analysed for the Silvertown Tunnel scheme are the Assessed Case against the two scenarios in which the charge was raised and lowered by 20% in each case (in the 2021 modelled year). The only difference between these scenarios and the Assessed Case is an increase or decrease in the modelled charge and so any change in flows can be attributed fully to the model's responsiveness to a change in charge. The identity codes for these model scenarios are as follows:

- 2021 Assessed Case – S142
- 2021 Assessed Case +20% Charge – S276
- 2021 Assessed Case -20% Charge – S277

8.1.7 The table below shows the outturn model charge elasticity when comparing the modified charge scenarios against the Assessed Case. The elasticities are colour coded by magnitude with green indicating higher elasticity and yellow indicating lower elasticity.

Table 2: 2021 Charge Scenarios Outturn Model Charge Elasticity (Benchmark: -0.1 to -0.4)

	+20% charge scenario against Assessed case		-20% charge scenario against Assessed case	
	Northbound	Southbound	Northbound	Southbound
AM Peak	-0.39	-0.37	-0.31	-0.29
Inter Peak	-0.28	-0.35	-0.22	-0.26
PM Peak	-0.23	-0.34	-0.18	-0.24

8.1.8 The key observations from these results are as follows:

- The range of modelled elasticities is -0.18 to -0.39 (with a mean of -0.29) which sits within the benchmark range of observed elasticities (-0.1 to -0.4) suggested by the studies researched above;
- The elasticities are lower in the -20% charge comparisons than in the +20% charge comparisons because lower charges result in higher levels of traffic and more delay. Under such circumstances a change in charge produces a bigger change in journey time and a smaller change in cost overall, which reduces driver response of making alternative travel choices; and
- There is variation in elasticities between individual time periods and directions which is likely to be as a result of levels of congestion on the Blackwall and Silvertown tunnels and alternative crossings, levels of service on alternative public transport options, journey purpose splits, and peak and off-peak charging

8.1.9 The next tables provide outturn model charge elasticities by user class. It is important to note that analysing the strategic model at this level of detail involves very small changes in flow which should not be relied upon absolutely. However, the results reveal that the model responds intuitively to differences in trip characteristics and traffic conditions.

Table 3: 2021 Charge Scenarios Outturn Model Charge Elasticity – Low Income Car

	+20% charge scenario against Assessed case		-20% charge scenario against Assessed case	
	Northbound	Southbound	Northbound	Southbound
AM Peak	-1.12	-0.69	-0.73	-0.50
Inter Peak	-0.38	-0.46	-0.37	-0.37
PM Peak	-0.38	-0.83	-0.32	-0.48

Table 4: 2021 Charge Scenarios Outturn Model Charge Elasticity – Medium Income Car

	+20% charge scenario against Assessed case		-20% charge scenario against Assessed case	
	Northbound	Southbound	Northbound	Southbound
AM Peak	-0.39	-0.41	-0.40	-0.48
Inter Peak	-0.40	-0.46	-0.27	-0.36
PM Peak	-0.23	-0.23	-0.17	-0.24

Table 5: 2021 Charge Scenarios Outturn Model Charge Elasticity – High Income Car

+20% charge scenario against Assessed case	-20% charge scenario against Assessed case

	Northbound	Southbound	Northbound	Southbound
AM Peak	-0.38	-0.41	-0.35	-0.34
Inter Peak	-0.30	-0.38	-0.27	-0.33
PM Peak	-0.26	-0.22	-0.24	-0.20

Table 6: 2021 Charge Scenarios Outturn Model Charge Elasticity – Car Business

	+20% charge scenario against Assessed case		-20% charge scenario against Assessed case	
	Northbound	Southbound	Northbound	Southbound
AM Peak	-0.08	-0.08	-0.03	-0.05
Inter Peak	-0.10	-0.12	-0.08	-0.07
PM Peak	0.02	-0.05	-0.01	0.01

Table 7: 2021 Charge Scenarios Outturn Model Charge Elasticity – Light Goods Vehicle

	+20% charge scenario against Assessed case		-20% charge scenario against Assessed case	
	Northbound	Southbound	Northbound	Southbound
AM Peak	-0.76	-0.39	-0.52	-0.17
Inter Peak	-0.22	-0.37	-0.15	-0.27
PM Peak	-0.24	-0.76	-0.18	-0.50

Table 8: 2021 Charge Scenarios Outturn Model Charge Elasticity – Heavy Goods Vehicle

	+20% charge scenario against Assessed case		-20% charge scenario against Assessed case	
	Northbound	Southbound	Northbound	Southbound
AM Peak	-0.35	-0.31	-0.13	-0.12
Inter Peak	-0.35	-0.38	-0.19	-0.18
PM Peak	-0.65	-0.26	-0.23	-0.04

8.1.10 There are a number of observations that can be drawn from these numbers:

- The elasticities for low income car users are the greatest in magnitude with a mean of -0.55. Medium (mean -0.34) and high (mean -0.31) income car users have elasticities which gradually decrease in magnitude as would be expected;
- The car business elasticities are the lowest in magnitude with a mean of -0.05 and some which are marginally positive indicating that in these circumstances they value the travel time savings associated with an

increase in charge more than the value of the increase in the charge itself;

- Light and heavy goods vehicles have mean elasticities of -0.38 and -0.27 respectively. The light goods vehicle mean is higher in magnitude than the high income car user mean but the medians are the same at -0.32 which is to be expected given their similar values of time. The heavy goods vehicle mean elasticity sits between the car business and light goods vehicle elasticities which is consistent with their relative values of time.
- Overall, the elasticities show that the model is responding as would be expected with user classes responding differently based on their values of time and journey purposes.

9. CONCLUSIONS

9.1.1 This note has set out the evidence to support the approach to modelling a user charge in the Silvertown strategic models. It demonstrates that the approach is in line with Government best practice, that the available evidence from local surveys does not suggest that the WebTAG value of time should be varied, that local variations in income across the study area are effectively accounted for at a strategic level and that the strategic model response to user charges is plausible, intuitive and in line with benchmarks from a range of international studies.

9.1.2 The strategic model response to the user charge, therefore, given the available evidence, is considered to be robust.

9.1.3 Further assurance can be taken from value of time sensitivity tests which show that the user charge, even with higher values of time, can effectively demand manage any flow impacts arising from the scheme.