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Comparing route choice behaviour under stop-&-go traffic between surveys involving textual description and driving simulator experience

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Abstract

Stop-&-go (S&G) traffic is a driving condition characterised by sudden braking followed by acceleration of vehicles. Cyclic occurrences of S&Gs can affect drivers to experience discomfort and create an unsafe driving condition. Past studies have independently conducted stated preference (SP) surveys and driving simulator experiments to understand route choice behaviour under S&G traffic. However, further research is needed in studying if a driving simulator experience prior to the SP survey could yield different results in comparison with an SP comprising description of the scenario. Two SP surveys, with university staff and students, were conducted to assess the route choice behaviour of individuals under S&G conditions. The first survey (SP1) involved introducing participants to S&G phenomenon through written text and animations before presenting the route choice scenarios. The second survey, SP2 was the same as SP1, except that the participants experienced S&G traffic in a driving simulator experiment before attempting the survey. The results from discrete choice analysis show that the mean value of time of drivers in SP2 dataset is 20% lower than SP1. The importance of this study is to understand the reasons for this difference which would potentially help in designing SP surveys which include the realism associated with the expensive driving simulator experiments.

1 Introduction

Traffic congestion is an increasing issue in society which impacts the way communities function. Not only does it create frustration among commuters, it leads to loss of productive person hours waiting in traffic which has a negative effect on a region's economy. Congested traffic eventually gives rise to a driving condition characterised by frequent starting and stopping of vehicles known as stop-&-go (S&G) traffic (Yeo and Skabardonis, 2009). S&G waves are often characterised by cyclic patterns of forced deceleration followed by acceleration (Shott, 2011). S&G traffic may also lead to unsafe and uncomfortable conditions for drivers. Due to these factors, drivers tend to avoid travelling on routes where S&G conditions are prevalent. Saxena et al. (2018) found that drivers were willing to travel for extra 16 seconds to reduce the occurrence of an additional S&G wave.

To quantify the route choice behaviour, information is generally gathered through a stated preference (SP) survey or simulation studies. An SP survey allows participants to respond to questions on a certain hypothetical situation which gives an understanding of their behaviour. However, these surveys are likely to induce a bias (measurement and hypothetical).which could lead to inaccuracies in results. A driving simulator study, on the other hand, is a virtual, computer-generated and controlled experience where participants are given a replication of a real-world scenario. Past studies have compared both SP and driving simulator and found interesting observations. For example, the study by Levinson et al., (2004) found contrasting results between SP and driving simulator experiments. However, further research is required to explore the difference between descriptive information and driving simulator experience before presenting the choice scenarios in an SP.

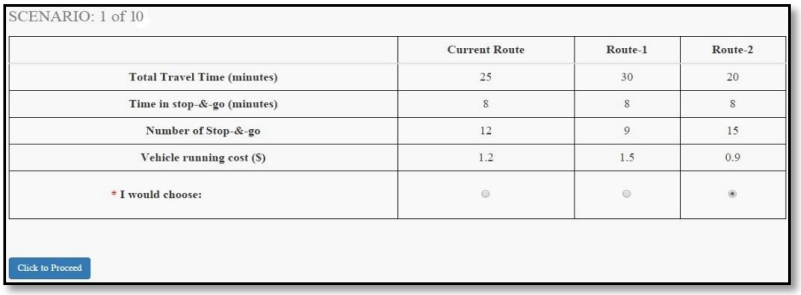
The aim of this paper is to study whether description of scenario presented in the form text and animation or a driving simulator experience could considerably influence route choice behaviour of individuals in an SP survey. This is done by comparing two stated preference (SP) surveys namely: SP1 where participants understood route choice behaviour through S&G traffic through written text and animations, and SP2 where the same SP survey was presented to the participants after driving simulator experience. The collected datasets are analysed using a random parameter logit (RPL) model which takes into consideration taste heterogeneity across individuals.

2 Datasets for analysis

2.1 SP Design

The SP experiment designed for this study was kept the same across SP1 and SP2 surveys. Each participant was presented 10 choice scenarios to understand their route choice behaviour. Each scenario comprised three alternatives which included the status-quo (currently chosen route) and 2 hypothetical alternatives.

Figure 1: Example SP scenario given to a participant


SCENARIO: 1 of 10

	Current Route	Route-1	Route-2
Total Travel Time (minutes)	25	30	20
Time in stop-&-go (minutes)	8	8	8
Number of Stop-&-go	12	9	15
Vehicle running cost ($)	1.2	1.5	0.9
* I would choose:	○	○	◉

Click to Proceed

The attributes used to define the alternatives were: travel time (TT), time spent in S&G conditions (TTS), number of S&Gs experienced (SNGO), and vehicle running cost (VRC). While the status-quo alternative remained invariant across scenarios, the attributes for the hypothetical routes were pivoted around the status-quo alternative, i.e. multiplying the status-quo with attribute levels. Figure 1 presents a choice scenario that was presented to one of the participants.

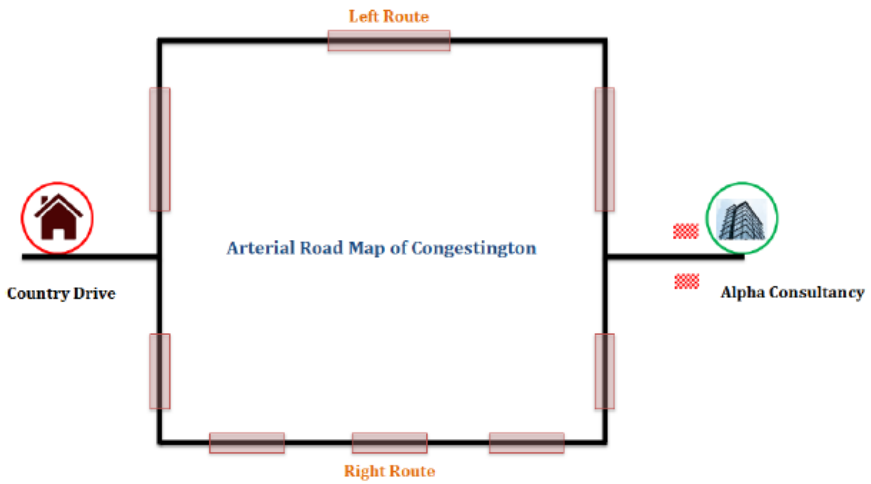
2.2 SP1 dataset

Participants were introduced to S&G phenomenon using a textual description followed by an animated video showing S&G traffic. The description of S&G waves shown was: “Stop-&-Go waves are characterised by the sudden braking, followed by acceleration, of vehicles. These waves are often prevalent in congested traffic conditions on urban road networks. Under stop-&-go conditions, vehicles are forced to decelerate and travel at slower speeds or even come to a halt, before accelerating again, many times over the duration of the trip.” The number of S&Gs was described as follows: “The number of times one experiences the situation of decelerating to a halt and then accelerating again while driving.” Similarly, the time spent in S&G traffic was defined as: “The travel time that you spend in stop-&-go traffic. This component of travel time is all included in the total travel time.” An animated video was shown to the participants to increase their awareness about this phenomenon. Responses from 145 participants were collected in SP1, which equates to 1450 observed route choice scenarios.

2.3 SP2 dataset

Participants in SP2 were given experience of driving under S&G traffic through a high-fidelity driving simulator. The driving simulator experiment consisted of three driving scenarios where each scenario involved driving on two routes namely: left and right routes. The intensity of S&G traffic was different across the three scenarios. Figure 2 shows the layout of the virtual driving scenario where the left route was designed such that it was longer (timewise) but had fewer S&Gs of longer duration when compared to the right route which had more S&Gs of shorter duration (smaller red boxes but more frequent. Once the participants completed the driving simulator task, they were asked to undertake the same SP survey, discussed in sub-section 2.1, which was conducted earlier in SP1. SP2 dataset comprised 101 participants, a different sample of university staff and students than SP1, which resulted in 1010 rows of observed route choice data. Readers can find more information on the driving simulator experiment in Saxena (2017).

Figure 2: Layout of the driving simulator task



3 Random parameter logit model

Hensher and Greene (2003) reviewed several applications of the mixed logit model in the field of transportation engineering. The model is particularly useful in SP

experiments where an individual is subjected to a series of choice scenarios. This is because the model captures correlations arising among alternatives and multiple choice scenarios and expresses the same in terms of preference heterogeneity among individuals towards the observed attributes. This particular specification of the mixed logit model is also called the random parameter logit (RPL) model. An RPL relaxes the IIA condition associated with the multinomial logit model by specifying a user defined mixing distribution for the parameters in addition to the idiosyncratic part which follows Gumbel distribution.

4 Results

The results from RPL for both datasets are presented in Table 1. The mean parameter for travel time is -0.286 which is more negative than its SP2 counterpart, -0.264. In other words, individuals are highly sensitive towards travel time increase when the S&G traffic condition was presented to them in the form of textual description. On the other hand, the mean parameter for the number of S&Gs is more negative (-0.129) in SP2 than SP1 (-0.0822).

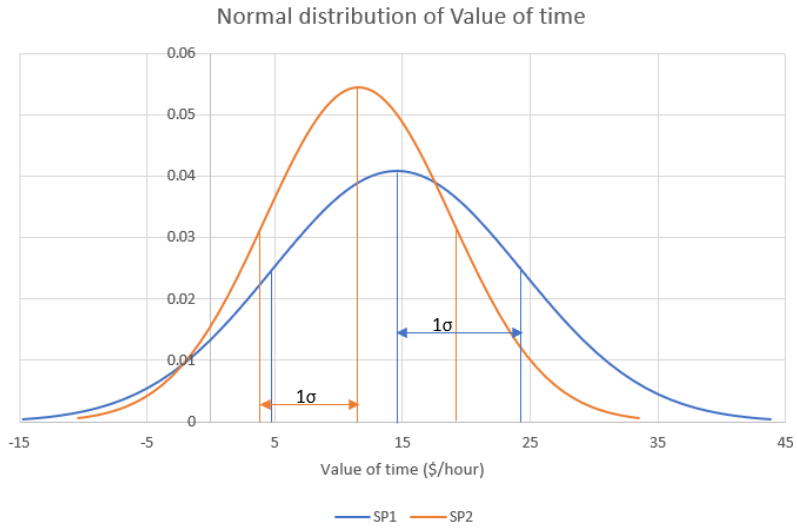
Table 1: RPL estimations for SP1 and SP2 datasets

Attribute	SP1	SP2
Estimated parameters	7	7
Number of observations	1450	1010
Null / Initial log likelihood	-1264.698	-920.816
Final log likelihood	-1119.434	-845.097
Rho – squared	0.115	0.082
Adjusted rho – squared	0.109	0.075
Mean of random parameters		
TT	-0.286 ***	-0.264 ***
TTS	-0.129 ***	-0.102 ***
SNGO	-0.0822 ***	-0.129 ***
Standard deviation of random parameters		
TT	0.192 ***	0.167 ***
TTS	0.0963 ***	0.0886 ***
SNGO	0.0672 ***	0.108 ***
Non-random parameters		
VRC	-1.18 ***	-1.37 ***
Value of time (VoT) in $/hr		
Mean	$14.54/hour	$11.56/hour
Std. Dev.	$9.76/hour	$7.31/hour

*** significant at 99%

The VoT for the two datasets is also calculated. The mean VoT is higher in SP1 ($14.54/hr) than in SP2 ($11.56/hr). This means that the participants are tolerant towards travel time increase when given driving simulator experience which leads to lower VoT. The VoT distributions are shown in Figure 3. The ANOVA test rejects the null hypothesis (the means of the two distributions are statistically the same).

Figure 3: VoT distributions for SP1 and SP2 datasets



5 Conclusion

The results from data analysis of the two datasets reveals that providing driving simulator experience lead to an increase in the sensitivity (57 percent higher than the corresponding value in SP1) towards the number of S&Gs. The VoT distributions emanating from the two datasets show that the mean VoT for SP1 was 20 percent higher than the corresponding value from SP2 dataset. Hence, this study shows that describing S&G conditions in an SP survey through text and animations produced different results in different route choice behaviour when compared to a driving simulator experience.

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