Reliability as Part of the Choice of a HOT Lane

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Abstract

The I-40 corridor in the Piedmont of North Carolina was studied as a potential site for a HOT lane. An add on to the main parts of the study was a set of stated preference questions about choices for commuters who use I-40 . The results of the study will be presented here with implications for other future analyses.

A study of consumer choice for a proposed high occupancy toll (HOT) lane in the Piedmont Triad of North Carolina is presented. Stated preference questions were prepared that included a measure of the frequency and the severity of travel delays along with the usual time and cost variables. Reliability was measured as the expected delay. For stated preferences responses, the HOT lane fee and the expected delay in general purpose lanes are found to be most important. The frequency of delay and its duration separately are not as important. Travel time was not a significant predictor of choice because of the relatively short commute.

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Scope and Objectives

Consumer choices in transportation have been of interest since their inclusion in forecasting mode choice in the traditional four step modeling process. Another application is the choice of lane when different conditions are offered on the same highway. Issues of lane choice became more important recently as more states have adopted value-pricing schemes to manage traffic flows and congestion as a part of travel demand and resource management. Two prominent measures of demand management are HOV and HOT lanes, which intend to encourage higher occupancy of vehicle and to reduce traffics. To be effective, these lanes need to provide faster and less congested traffic flows, which depend on commuters' choice of lane.

The choice of lane has been studied in prior studies using both revealed and stated preferences. Lam and Small (2001) studied the choice between a free and a variably tolled route and computed the value of time and value of reliability. Brownstone and Small (2005) found that travel time, cost, reliability and personal preferences were predictors of choice of lane.

Perhaps the interesting outcome of these studies is the relative influence of reliability. Compared to travel time, Brownstone and Small found that the influence of reliability was about 2/3 of the influence of time. They measured reliability as variability.

For measures of reliability for revealed preference (RP) data, reliability has become part of the standard network measures (,2003). There are two basic network measures of reliability: variability and percent late arrival. Dispersion can be either the range or the standard deviation. Percent late arrivals require detailed measures of actual and planned arrival times and the frequency of occurrence.

For stated preferences, consideration must be given to the ability of respondents to understand the implications of the factors for making decisions. Previous measures have included variability and times late.

The objective of this paper is to introduce an alternative measure of reliability and to examine the effect of reliability on choice between a HOT lane and general purpose (GP) lane. This measure is a combination of commonly-used reliability measure of "buffer index" and a statistical measure of "probability" which reflect a variability measure. The new reliability measure inherits strengths of both of reliability and variability measures.

Literature Review

The choices of traveling on a conventional general purpose lane or in a value priced high occupancy toll (HOT) lane has been studied by Brownstone and Small (2005) who examine costs and reliability of drivers on a value pricing demonstration. They use variability of travel time as an inverse measure of reliability. Alvare et al (2007) examine costs and choices between conventional and value priced lanes for trucks using stated preference techniques.

Reliability has been examined in several recent papers. Three measures of reliability are examined: range coupled with the probability of lateness, the standard deviation of travel time ane time moment of inertia. Reliability is valued highly but differently in each case.

Lyman and Bertini (2008) tested several measures of reliability including travel time, 95th percentile travel time, a travel time index, a buffer index and congestion frequency. The study examines both system-wide and highway segment applications.

Tu et al (2008) define travel reliability as made up of both the variability of travel times and the predictability of travel times which is related to the probability of traffic breakdowns. They develop a formula and apply it to a network analysis.

The North Carolina Piedmont Triad Study

A questionnaire was prepared to investigate the potential use of a new HOT lane on I-40 in the Piedmont Triad. The questionnaire was distributed in two parts. The first part was a description of commuting travel on I-40 to the Greensboro, NC metropolitan area. The second part was the measurement of attitudes and stated preferences.

For the SP a possible HOT lane was first described as located on I-40. In the SP questions a week of commuting was split between the general purpose lane, carpooling on the HOT lane and driving on the HOT lane.

The most important determinants of lane choice between free lane and HOT lane are the cost of the HOT lane, the time savings while using the HOT lane, the time savings, the length of unexpected delays on the general purpose lane and the frequency of the unexpected delays. Data were presented in a Greco-Latin Square which is summarized in Table 1. General purpose and HOV lanes were free. The HOT lane was tolled.

Drivers were identified at the end of exits from I-40 near Greensboro and the first part of questionnaires were handed out. They mailed the questionnaire back. Then, the second part was given as a follow-up survey and answers were collected by telephone. Data for both parts were included together.

Reliability is measure as the "expected delay" which is found as the product of the probability of delay (the number of delays divided by the commuting days in a month) times the length of the delays. Unlike the statistical variability measures such as standard deviation of travel time, a probability of delay is easier for respondents to understand on surveys. The probability measure is also related to the "on-time arrival" rate used as a tardy trip indicator. The length of delay is the same as buffer time without explicit on-time arrival rate of commonly used 95 percent.

Analysis Results

A summary of descriptive statistics is presented in Table 2. All respondents were commuters, most were professional/managers, men with middle income (about $70,000 annual family income).

The analysis of the SP data was by a logit analysis and is summarized in Table 3. The dependent variable is the use of the HOT lane versus the general purpose lane. The χ^2 was 471 with 11 degrees of freedom which was highly significant and the pseudo R^2 was .28 which is acceptable. The cost is the difference between the cost of the HOT lane and the GP lane. Cost is the largest coefficient and t value and expected reliability is the largest coefficient and t value of the other decision variables. The total number of trips taken in a week and the five attitudinal factors were also significant predictors. It was interesting that the time savings for using the HOT lane was no a significant predictor.

The expected reliability is the driving variable for the use of HOT lanes. Time savings is insignificant and has a much smaller coefficient.

The Value of Reliability

Brownstone and Small (2005) illustrates the calculation of the value of reliability which is similar to the calculation of the value of time. For these respondents the value of time is:

$$VOT = b_t / b_c = .03 / -.77 = -.04.$$

and the value to reliability is:

$$VOR = b_r / b_c .= .61 / -.77 = -.80 .$$

The calculated value of reliability is 20 times as much as the calculated value of time.

Conclusion

The time – cost tradeoff that is the traditional corps of travel decision modeling in this case is highly influenced by the reliability of the planned lane. This in part reflects the design of the experiment. Prior studies have looked at measures of variability that are cross-sectional and may understate the importance of reliability.

The expected value interpretation of reliability is strong compared to lateness or frequency alone. Compared to measures of variability specific measures of reliability relate to the needs of travelers who can plan ahead to take extra time if they know that they need it. It has been said that " The best surprise is no surprise".

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Table 1 Factors and levels for the stated preference questions.

Factor	Description	Level		
		1	2	3
I (A)	Drive alone travel time savings	0	10	15
I (B)		0	7	10
I (C)		0	3	5
I (D)		0	3	5
II	Toll ($)	0.25	2	3
III	Unexpected delays in current lanes	1	2	4
IV	Delay time in current lanes(Minutes)	5	10	15

Table 2 Descriptive analysis of respondents

Variable	Mean	Std Dev	Responses
Percent who carpool	8%	0.27277	136
Percent who used bus	21%	0.40976	136
Adult riders	2.00	0.74181	147
Child riders	1.34	1.07228	89
Licensed drivers	2.12	0.76803	150
Number of vehicles	2.56	1.37366	150
Gender(female)	46%	0.49858	150
Race (white)	84%	0.51792	147
Income	$70,000*	0.89861	125

- approximate

Table 3 Model of the Probability of Choosing a HOT Lane

Variable	Coefficient	Standard Error	b/St.Er.	P[Z>z]	Mean of X
Q11	-0.39	0.08	-5.12	0.00	2.20
Q13	0.00	0.00	-3.04	0.00	-10.58
Q14	0.00	0.00	2.97	0.00	-25.02
Q18	0.20	0.05	3.94	0.00	2.61
Q24	-0.20	0.07	-2.71	0.01	3.18
Q27	0.31	0.08	3.97	0.00	2.52
Q32	-0.24	0.07	-3.55	0.00	-3.79
AM_D1TOT	0.45	0.06	7.91	0.00	-71.34
AM_EXPEC	0.61	0.09	6.51	0.00	0.43
D1_CO	-0.77	0.06	-11.98	0.00	0.83
AM_D1_CT	0.03	0.02	1.45	0.15	9.25

Key:

1 – strongly agree to 7 strongly disagree.

Q11. I like the flexibility that driving allows.

Q13. Highway travel is safe.

Q14. Carpool-only lanes should be available on I-40.

Q18. It is hard to find carpoolers.

Q24. I like to be always on time.

Q27. Charging a toll to use a managed lane is fair..

Q32. In your opinion, if tolls were collected to allow single drivers on carpool lanes, how should the money be used? To maintain/improve all other roads in the area.

AM_D1TOT - the total trips to be taken in the morning on all lanes.

AM_EXPEC - the expected delay for the general purpose lane.

D1_CO - the cost for a single driver to use the HOT lane.

AM_D1_CT - the time savings for using the HOT lane.