Evaluating Subjective Beliefs of Travel Time of Taxi Drivers

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Abstract

Uncertainty in traffic network is very common, and drivers are faced with these in their daily choices with respect to routes and departure times. Transportation engineers have identified that the risk attitudes and perceptions of risk are important components of risks in transportation system and affect drivers’ decisions. This risk perception (travel time distributions) can be significantly different from the actual distributions. This research aims to study individual’s belief regarding travel time, and what does stated ranges mean with regards to perception of uncertainty in travel time. A controlled field experiment was conducted in Dhaka, Bangladesh, using a representative sample of 101 taxi drivers between 19 and 55 years of age. The experiment was conducted over a road network with choice of two possible routes. This study uses methods from experimental economics to elicit subjective beliefs about travel time, with real monetary rewards. These monetary consequences are dependent based on actual travel times. We find distinct differences in the perceived beliefs of travel time and those actually observed. This finding is significant for transport planners conducting cost benefit analysis to determine transportation demand management strategies. Neglect in incorporating perception into travel behaviour models could bias results. In addition, strategies such as information provision need to be explored to reduce these perception biases.

Keywords: Experimental economics, Subjective belief, Uncertainty in Travel Time
1. Introduction
Uncertainty in traffic network is very common, and drivers are faced with these in their daily choices with respect to routes and departure times. With findings suggesting people associating high value over reliability, it is critical to understand how people perceive these uncertainties, and whether or not they closely represent the travel times that are actually observed. Understanding individual’s perception regarding these uncertainties (Dixit et al., 2012) in a traffic network is closely linked to the aim of predicting travel as well as economic behaviour. It is also important to understand drivers’ beliefs towards travel time distributions to better understand route choice and departure time choice.

Travel time perceptions are usually reflected in common parlance as: “the travel time on route X is between \( t_0 \) and \( t_1 \)” As part of this study we attempt to analyse beliefs inferred from such stated parlance, as well as elicit these ranges through an incentive mechanism and compare it with actual observed travel times. In this paper, we conduct a field experiment with taxi drivers in Dhaka, Bangladesh. Incentives are used in experimental economics to gain control. It is being widely used to conduct laboratory experiments to study theory and models regarding equilibrium (Ziegelemyer et al., 2005; Selten et al. 2007; Ramadurai and Ukkusuri 2007) and Braess Paradox (Rapoport et al., 2005), information and its effects on route choice (Avineri and Prashker, 2005), individual behaviour and route choice under uncertainty (Dixit et al. 2013) as well as safety (Dixit et al. 2011). In addition, Hartman (2006) explored monetary and direct time costs between a congested and less congested route, and identified the effect of subject heterogeneity in value of time preferences between different subject groups. An important aspect to recognize is that all these studies were based in laboratories to test theories, and very limited research has been conducted with field experiments to understand travel behaviour.

Several studies in both economics and psychology have focused on beliefs over risk. Some researchers have examined the perception of risk has influence on driving behavior (Ranney, 1994; Deery, 1999; Chaudhary et al., 2004). Risk acceptance is one of the major characteristics that explain risk taking behavior of drivers was also identified by Deery (1999). Also, various studies have focused on survey based instruments to measure perception of risk (Rundmo and Iversen, 2004; Corbett, 2001; Hatfield et al., 2008; Greaves and Ellison, 2011).

The main contribution of this paper is the use of methods from experimental economics to develop a method to elicit individual beliefs, and compare them to actual observed travel time distribution, as well as those stated without incentives. From a policy point of view we find that drivers are underestimating their beliefs of travel time.

The paper is structured as follows. Section 2 describes the details of the experimental design. Section 3 describes our findings on beliefs of drivers using travel time distribution plot before we close the paper with some conclusions and directions for future research.

2. Experimental Design
The study area of this research is located in the southeast part of Dhaka Metropolitan City and is stretched over Ramna and Kakrail suburbs of Dhaka city. It is located between \( 23^\circ\ 41' \) and \( 23^\circ\ 48' \) north latitudes and between \( 90^\circ\ 22' \) and \( 90^\circ\ 31' \) east longitudes.
Figure 1 shows a map of the study area, with the relevant routes coloured red and blue. Two alternative routes, 1 and 2, were suggested. Route 1 comprises with a portion of Minto Road and Hare Road and it is 1.2 kilometres long. Route 2 is 1.4 kilometres in length and it covers a part of Ramna Road and Bhashani Road. Route 1 is usually less congested and has some scenic views. In this field experiment 101 taxi drivers in Dhaka city were randomly hired at the origin of the selected road network (Figure 1).

![Figure 1: Road network used in the study area](image)

### 2.1 Experimental Setup
The research was conducted through face-to-face interviews and driving experiment during the morning peak period (8:30 am – 10:15am) from origin to destination as shown in Figure 1. The study period lasted from 15th of November, 2012 to 3rd January, 2013, and the experiments were conducted only on weekdays.

The duration for which the participating taxi drivers held their drivers license ranged from 1 to 30 years. Each subject was identified by a unique ID number. At the beginning of the sessions, the participants were offered 15.00 Bangladeshi Taka (BDT) [1US$ ≈ 75 BDT] to participate in the experiment, and could refuse to participate at any point during the experiment. There were no participants who refused or dropped out from the experiment.

Instructions for the experiment were provided in the instruction handout and subjects read through the instructions while the experimenter read them aloud. For ease of subject’s understanding the instructions were translated into Bengali, first language of Bangladeshi population by the professional translator. The experimenters followed the same script and procedures for each subject, documented in Harrison et al. (2004). The experiment was comprised of four parts, which were presented to each participant.
2.1.1 Questionnaire Task
The main purpose of this part of the experiment was to identify driver demographics and the characteristics of their beliefs. The questionnaire survey instrument collected two types of information from each subject. First it collected demographic information such as age, gender, income, highest level education, marital status, taxi ownership and so on. The driver demographics are provided in Table 1.

The second portion of the survey instrument collected information about personal belief related to travel times on two alternative routes. As part of this task the drivers were asked to state their beliefs regarding the travel time range on the two routes.

**Table 1: Data summary of participants**

<table>
<thead>
<tr>
<th>Variable</th>
<th>Group</th>
<th>Frequency</th>
<th>Percent</th>
<th>Cumulative Percent</th>
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<tbody>
<tr>
<td>Age</td>
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<td>1</td>
<td>0.99</td>
<td>0.99</td>
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<tr>
<td></td>
<td>22-25</td>
<td>6</td>
<td>5.96</td>
<td>6.95</td>
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<tr>
<td></td>
<td>26-30</td>
<td>13</td>
<td>12.89</td>
<td>19.84</td>
</tr>
<tr>
<td></td>
<td>31-40</td>
<td>45</td>
<td>44.48</td>
<td>64.32</td>
</tr>
<tr>
<td></td>
<td>41-50</td>
<td>33</td>
<td>32.69</td>
<td>97.01</td>
</tr>
<tr>
<td></td>
<td>51-65</td>
<td>3</td>
<td>2.99</td>
<td>100</td>
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<tr>
<td>Gender</td>
<td>Male</td>
<td>101</td>
<td>100</td>
<td>100</td>
</tr>
<tr>
<td>Income</td>
<td>Less than Tk. 100</td>
<td>14</td>
<td>13.86</td>
<td>13.86</td>
</tr>
<tr>
<td></td>
<td>Tk. 100 – 300</td>
<td>87</td>
<td>86.14</td>
<td>100</td>
</tr>
<tr>
<td>Marital Status</td>
<td>Single and never married</td>
<td>13</td>
<td>12.87</td>
<td>12.87</td>
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<tr>
<td></td>
<td>Married</td>
<td>88</td>
<td>87.13</td>
<td>100</td>
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<tr>
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<td>46.53</td>
<td>46.53</td>
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<tr>
<td></td>
<td>Secondary school school</td>
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<td>45.54</td>
<td>92.07</td>
</tr>
<tr>
<td></td>
<td>Less than secondary school</td>
<td>8</td>
<td>7.93</td>
<td>100</td>
</tr>
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<td>28.72</td>
<td>28.72</td>
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<tr>
<td></td>
<td>Renting</td>
<td>72</td>
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<td>100</td>
</tr>
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<td>Holding DL</td>
<td>0-5 years</td>
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<td>8.91</td>
<td>8.91</td>
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<tr>
<td></td>
<td>5-10 years</td>
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<td>41.58</td>
<td>50.49</td>
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<tr>
<td></td>
<td>11-20 years</td>
<td>42</td>
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<td>92.07</td>
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<td>21-30 years</td>
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<td>HH number</td>
<td>2 or less</td>
<td>11</td>
<td>10.89</td>
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<td></td>
<td>5-6</td>
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<td>28.71</td>
<td>100</td>
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</table>

2.1.2 Incentivized task
We also introduced an incentivized task, through which we elicit subjective ranges over travel time. Each route has different travel time and each individual has different perception on their belief. In this task
there were two routes from origin to destination as described in earlier section. The participants were instructed that their final monetary payoffs depended on the range of travel time \((t_0 - t_1)\). This stated range can be different from those they stated earlier without any incentives. The final monetary consequence \((M)\) was determined by flipping a coin to determine one of the two routes to be driven on. If the driver was able to reach the destination in the stated range \((t_0 - t_1)\), they would receive an amount of money \(M\), which was calculated as:

\[
M = \frac{100 - \frac{(t_0 + t_1)}{2}}{t_0 - t_1}
\]

For example, if the subject selected a targeted travel time range as 20 – 25 min, this meant that the final pay off will be: \(\{100 - (20+25)/2\}/5 = 15.50\) BDT. The numerator ensured that the monetary consequence depended on how quick they can believe they can get to the destination. While the denominator ensured that the as the drivers did not overstate their range, i.e. if they mention a larger range their monetary payoffs reduce. In order to ensure incentive compatibility, subjects were usually informed that they had to drive at a normal speed and must follow the traffic rules.

3. Results
We explore whether individual beliefs on travel times differ from actual observed travel time distributions, and whether incentives have any effect. Figure 1 shows the travel time distribution for the observed travel times on Route 1 and Route 2. It is clear that the travel times on Route 2 are larger than Route 1, reflecting the fact the Route 2 is more congested. The travel times were collected during the same periods, and included data from taxi drives as well as other trips made on these routes during the same time period. There were 139 observations on Route 1 and 63 observations on Route 2.

![Distribution of Observed Travel Time](image)

**Figure 1: Distribution of Observed Travel Time**

Figure 2 and Figure 3 represent the difference in travel time range (i.e., \(t_1 - t_0\)) for those stated under non-incentivized and incentivized contexts on route 1 and route 2 respectively. The distribution was
generated by pooling data collected from all the taxi drivers. The kernel density was estimated using STATA. A comparison of the two figures does not suggest any significant differences between the two distributions. Further, statistical tests using a pooled t-test did not provide any evidence for a statistically significant difference between the stated distributions between the non-incentivized and incentivized options.

Figure 2: Difference in Travel Time Range for Route 1. The red line representing data reported under non-incentivized conditions, and the blue line representing those under incentivized conditions. Travel time is represented in seconds.
Figure 3: Difference in Travel Time Range for Route 2. The red line representing data reported under non-incentivized conditions, and the blue line representing those under incentivized conditions. Travel time is represented in seconds.

Figure 4 and Figure 5 illustrate the travel time distribution for route 1 and route 2 respectively, for the non-incentivized, incentivized and actual travel times. The mean travel times were determined from the stated ranges and pooled together to determine the kernel distribution for the non-incentivized and incentivized beliefs of travel times. The two graphs suggest that drivers are underestimating their beliefs on travel time on both routes, under incentivized and non-incentivized conditions. The degree of underestimation is higher in route 2 than that of route 1. In fact, on route 2, which is the congested route, the incentivized travel time distribution is lower than the non-incentivized.

To test the statistical validity of any differences, we conduct an F-test to compare the variances. The variances for non-incentivized and incentivized reported travel times on route 1 were found to be not statistically significantly different (p-value=0.44). However, both the variances of the non-incentivized and incentivized stated travel times were statistically different from the actual travel times, with p-values of 0.02 and 0.03 respectively. The stated variances were smaller than those actually observed on route 1. The mean travel times between the non-incentivized and incentivized stated travel times were not statistically significantly different (p-value=0.40). However, the mean travel times between the stated and actual travel times were statistically different. The stated travel times were statistically lower than the actual travel times.
Figure 4: Travel Time Distribution in Route 1. The red line representing data reported under non-incentivized conditions, and the green line representing those under incentivized conditions. The blue line represents actual observed data.

Figure 5: Travel Time Distribution in Route 2. The red line representing data reported under non-incentivized conditions, and the green line representing those under incentivized conditions. The blue line represents actual observed data.
The variances for non-incentivized and incentivized reported travel times on route 2 were found to be statistically significantly different (p-value=0.001). In addition, the variances of the incentivized stated travel times were statistically different from the actual travel times. However, the variances of the non-incentivized stated travel times were not statistically different from the actual travel times. The incentivized stated variances were smaller than those actually observed on route 2. The mean travel times between the non-incentivized and incentivized stated travel times, as well as those stated and actual were statistically different. The stated travel times were statistically lower than the actual travel times.

Overall these findings suggest that the travel time beliefs have lower variances and lower mean travel times than those actually observed.

4. Conclusion
We find that drivers are underestimating the perceived probability distributions of travel times. The level of underestimation is higher in the case of route 2, which is congested. This paper opens a new area of future research by exploring the variables could affect the individual’s beliefs of travel time during route choice process. Further investigation is needed to identify how the belief of driver could influence the route choice decision differently from previous other literature. To do this it is necessary to develop a route choice model which incorporates driver’s risk attitudes and beliefs of travel time.

5. References
Kuhmo Nectar Conference for Summer School of Transportation Economics Annual Conference of the ITEA, Stockholm, Sweden, June 27-July 1 2011
Dixit, V. V., C. Wilmot and B. Wolshon 2012 Modelling Risk Attitudes in Evacuation Departure Choice, Transportation Research Record, Volume 2312 / 2012, pg. 159-163