A GPS-based Route Choice Analysis under Mixed Traffic and Roadway Conditions in a Developing Country

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Introduction and Motivation

Individuals’ route choice decisions form a key component in transportation demand modeling with applications to congestion management, traffic operations, and infrastructure planning, route guidance, and vehicle operating costs. Commonly used traffic assignment models are mainly based on the shortest travel time or distance between origin and destination. Studies in developed countries show that there are several other factors that influence the route choices.

The main motivation is that few studies on route choice in developing countries focus on mixed traffic and roadway factors on route choice, due to difficulty of collecting such data. However, several other potential factors including non-uniform road geometric, varying composition, variable roadway condition, side friction etc are likely to influence route choice in such contexts. Second, in developing countries there are a significant proportion of two-wheelers with very different operating and behavioural characteristics (speeds, parking ability, manoeuvrability, response to congestion etc.) than cars. The differences in route choice between different classes warrants a systematic examination with implications for congestion mitigation and safety improvement.

Therefore, this study aims to study the effect of these factors on route choice behaviour in Chennai, India by combining observed route choice data from GPS with other data pertaining to mixed traffic at the network level. Specifically, the objectives include: 1) to examine the effect of various traffic and roadway related factors affecting route choice behavior of commuters and 2) to study the heterogeneity in responsiveness of two wheeler and four wheeler drivers towards these factors.

Data and Methodology

The data for this study primarily comes from a real-world commuter route choice survey from five zones in Chennai, India. Two wheeler and four wheeler commuters carried a GPS device during their commute trips on a weekday. Later, each of the respondents answered a questionnaire on factors related to roadway and traffic conditions. There were 337 usable responses from the survey.

Mixed traffic characteristics constitute an important set of factors as typical peak hour traffic composition of Indian cities is highly heterogeneous comprising a mix of four wheelers, two wheelers, auto-rickshaws (three wheelers), bicycles and heavy vehicles (buses and trucks). The mixed traffic and roadway related factors considered in the analysis include vehicle type, mixed traffic composition, road surface condition, presence of median and number of bus stops and signals present. These factors play an important role in determining the vehicle operating cost, safety, travel time, ride quality and reliability of different routes, which are not given adequate attention in developing countries.
The objectives are addressed by the following approach: 1. recording the chosen route using GPS, 2. constructing the choice set, 3. determining the mixed traffic variables at the network level, 4. obtaining attitudinal variables from a user survey and 5. segmentation analysis of route choice by two-wheeler and four-wheeler users.

To obtain the choice set, a universal choice set of 200 shortest travel time paths for each user’s O-D pair is obtained by performing a user equilibrium assignment for the entire city network. It was found that the difference between the first and 200th path was less than 10 minutes in most cases. Further, nearly 81% of the chosen path travel times fell in this range. Five random paths are picked from this universal choice set to constitute the alternative choices other than the chosen path for each respondent.

The main challenge in building real-world route choice models is that attributes and mixed traffic related data on alternate paths are not directly obtained. A host of secondary data sources are used to obtain data about these traffic and roadway elements and integrated into a GIS database at the link level for the entire network. For instance, the congested link-level travel time, congestion, speed are obtained from the traffic assignment model and aggregated across the various path alternatives. Mixed traffic data such as bus-stops, median presence, and signals are assembled from various traffic and transit sources extracted for each path. The data from citywide traffic census were used to obtain link level traffic compositions. In the absence of other data, the roadway condition was estimated using a roadway deterioration model based on volume of traffic and age of the pavement on various links of the network. The link level data are then suitably aggregated at the path level.

Using the five alternative paths along with the chosen path as the choice set, route choice models are estimated using a multinomial logit model. A segmentation analysis is used to differentiate route choices of two-wheeler and four-wheeler users. The models will be further refined to include correlations through path size logit model.

Results
Exploratory analysis from the GPS data reveal interesting insights into the route choice behavior of commuters under mixed traffic. Nearly 63% of respondents chose a path with less than 50% overlap with minimum travel time path. A similar trend (nearly 66% users) is seen for the minimum distance path. Thus, contrary to common perception, travelers might tend to consider other factors apart from distance and travel time while choosing routes. The data also confirms that route choice occurs in highly congested conditions, with 93% of trips having an average speed of less than 30kmph and, nearly 30% of the commute travel time occurring at speeds less than 5 kmph (on the chosen route). The GPS and questionnaire data also suggest differences in route choices of two-wheeler and four-wheeler users in terms of average speeds and number of bus-stops en-route.

The mixed traffic variables significantly improved the model goodness of fit to a $\rho^2$ value of 0.54 indicating their importance. Key differences are also observed between two wheeler and four-wheeler users. The model results suggest a tendency of users to avoid routes with more bus stops and higher bus composition due to the interruption to flow.
due to their stoppages at mid-block locations. Further, the results show that road surface condition is an important route choice factor implying that commuters are sensitive to vehicle operating costs and desire better comfort while driving. Commuters also preferred routes with fewer signals to reduce waiting times, and consequently traveled on lower capacity minor roads with lower speeds for some portion of their commutes. This may explain the deviation from the minimum travel time routes noted earlier.

Market segmentation analysis of two wheeler and four wheeler drivers revealed heterogeneity in response sensitivity towards road condition, travel time and traffic composition. For example, the results indicate that two wheeler drivers are more sensitive to fuel cost, travel time and road surface condition. For these reasons, two wheeler drivers may not mind taking detours through minor roads to avoid the pollution, stress and discomfort of congested main roads. Four wheeler drivers might be more insensitive to travel time and road surface condition, given the comfort and better driving conditions that they enjoy. These differences have important implications for infrastructure investment, congestion mitigation, and demand management.

Conclusions
To summarize, this is one of the very few studies in developing countries that attempt to objectively capture the commute route chosen through GPS devices at a real-world, city wide network. Specifically, this study examines route choice in relation to the prevailing mixed traffic conditions. The route choice model results highlight the significance of these factors and seem to suggest that conventional traffic assignment models based only on shortest time or distance do not describe the route choice behavior accurately. Another distinguishing feature is the analysis of heterogeneity in route choice behavior among two wheeler and four wheeler drivers. This heterogeneity may be used to provide suitable information to different classes of users with applications to traffic segregation for improving efficiency and safety in mixed traffic. Finally, the model results can be used to more realistically assist in location decisions of bus stops, median and prioritizing road surface maintenance and associated road user costs to different classes of users.