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Activity-Based Tour Generation Model with Peshawar as Case Study

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ABSTRACT. *The forecasting of travel demand is an important step in the planning of an efficient transportation system. Transportation planners need accurate information about the capacity of the current system and their prediction of the future demand should have a strong basis. Earlier, Travel demand models used a statistic-based approach towards predicting travel demand which gave a macroscopic view of the problem and did not consider the decisions of an individual or the reasoning behind those decisions. However, an individual does not travel without any reason. The need for travel arises from the need to partake in different activities. A behaviour-oriented travel demand model that takes into account the behaviour of the individual is the need of the hour. In this study, an activity-based tour generation model for a small and unplanned metro area, in this case, Peshawar (Pakistan), was developed. Multinomial logistic regression was used for modelling. The results generated from the model were tallied and closely correlated with manually collected data.*

Keywords: Travel Demand, Demand Analysis, Activity Based Modelling, Travel Behaviour, Tour Generation, Traffic Forecasting.

1. INTRODUCTION

Travel Demand is the capacity of a transportation system required to meet the need of the population. Travel demand forecasting is the process by which the travel demand for a region is predicted. This helps the planners, to plan the characteristics of a transportation system in order to meet the demand. Travel demand models are used to predict travel characteristics and the effect of the economic and social attributes of the individuals on the usage of the system.

Travel demand is the numerical relation between the behaviour of the populace, the features of the system and the travel demand.[1] It includes the response of the transportation system to changes in its characteristics and also changes in the behaviour of the populace using the system. A Travel Demand Model predicts the use of different transportation systems based on the social and economic conditions of the demographic using the system.[2]Earlier models used for travel demand modelling were more statistic oriented. These models gave a macroscopic view of the problem but did not consider the behaviour of the populace on an individual level.[3] In recent years, the focus has changed to more activity and behaviour-oriented models. In this study, an activity-oriented tour generation model and mode choice model will be developed for Peshawar.

There is a lack of proper planning for transportation systems in developing countries such as Pakistan. In Pakistan, older statistical methods are used to predict the future needs of the transportation system. A behaviour-oriented traffic demand model which takes into account the impact of an individual's activities on the need to partake in travel is the need of the hour. As it would lead to a more efficient system and less consumption of fuel by helping in policy planning.

For this study, we will predict the travel demand for Peshawar by developing a behaviour-oriented tour generation and mode choice model. A multinomial logistic regression model will be used for developing the Tour Generation Model.[4] The tour types used in the modelling process are work-based, Academic, Recreational,

Shopping/Other. The attributes selected for the study are the number of members in a household, number of working family members, number of children, age, household income, and vehicle ownership.

2. LITERATURE REVIEW

2.1 Travel Demand Analysis

Travel Demand Models are employed to forecast future requirements of the transportation system. These models change with a variation in either the features of the transportation system/infrastructure or the public using the transportation system or both. More explicitly, Travel Demand Models are employed to foresee a change in travel characteristics and usage of transport services under alternative socioeconomic circumstances and land-use configurations. Activity schedules are used to estimate the time-based travel demand along with the ability to alter the schedules according to changes in travel options.[5]

In the 1970s, the focus of transportation planning deviated towards policy-based planning from a more regional approach to planning, where along with the response of a system, the importance of individuals' reactions is essential. More behaviour-oriented activity-based models had started replacing the old-style statistic-oriented Trip-Based Models.[6]

2.2 Trip-Based Travel Demand Models Developed in the 1950s, these earlier models used individual trips as a unit of analysis and comprised up of four sequential phases:

a) Trip Generation
b) Trip Distribution
c) Mode Choice
d) Route Choice.

This method has two main types;

i) 'Aggregate Trip Based Models'[7]
ii) 'Disaggregate Trip Based Models'.

The limitations of the trip were that it ignored the fact that demand for travel arose from the need to perform different activities. It relied on the individual trip and focused on the individuals, ignoring the influence of the household on the decision-making of an individual.[3,6]

2.3 Activity-Based Travel Demand Models

Activity-based models are the third generation of travel demand models, which have attracted significant interest since the 1980s. Activity-based or behavioural modelling of travel demand treats the need to travel as being a consequence of the need to partake in activities.[8] Activity-based models are better at replicating the travel decisions made by an individual and are, therefore, better at forecasting future travel patterns. This method was based on the work of Torsten Hagerstand. Hagerstrand hypothesized that a person's actions were constrained by several individual and social characteristics.[9]

In his famed 'time-geography theory', he stated that individuals live in a time-space prism in which an individual can function in different places at different points by undergoing travel and experiencing its cost in the form of time and money. Therefore, the theory supposed that the need to partake in travelling to a certain place, at a certain time of the day and by a certain travel mode is a consequence of the demand to partake in an activity. In order to estimate travel demand, accurate activity schedules are required. In activity schedules, individuals are supposed to have several activities that have to be accomplished in a certain time.[3]

3. METHODOLOGY

Data collection was carried out using questionnaire surveys in Peshawar, Pakistan. Each household was given a questionnaire to fill in basic information about the household and a trip diary to log in their travel detail. Data collected in the survey consists of the trip type, Departure time of the trip, Purpose of the trip, mode choice and duration of the trip. The trip type included home-to-work, work-to-home, recreational trips, shopping trips, and other miscellaneous trips.

Of the total 7000 questionnaires distributed, 1130 questionnaires were returned. Of the 1130, 330 were either incomplete or incorrectly filled.[10] 800 questionnaires were used for modelling. A further 50 households' data was recorded, which was used to calibrate and validate the model.

After the collection of data, the data was statistically analysed using SPSS and MS Excel. The variables turning out significant (such as the number of members in a family, those of them who work, the number of children in a family, the financial income of the family, the ages of the individuals, and whether the family owns a vehicle) in the model are given in Table 1. The trip data was converted to tours. The types of tours are in Table 2.

Table -1: Attribute and Attribute Class

Sr. No	Attribute	Attribute Class	Variable
1.	Family Members	-	A
2.	Working Family Members	-	B
3.	Children	-	C
4.	Income	Rs. 0-20000	D_1
		Rs. 20000-40000	D_2
		Rs. 40000-70000	D_3
		Rs 70000-100000	D_4
		Rs. >100000	D_5
5.	Age	<30 years	E_1
		>30 yeras	E_2
6.	Vehicle Ownership	Yes	F_1
		No	F_2
7.	Number of Households	-	N

Table -2: Tour Types and Their Descriptions

Sr. No	Tour Types	Description	Symbol
1.	HRecH	From home for recreational purposes and back home.	H_{Rec}
2.	HWH	From Home to work and back Home	H_{work}
3.	HSH	From Home for shopping and back Home.	H_{Shop}
7.	HScH	From Home to an educational institute and back.	H_{edu}

The data was analysed using a statistical analysis package. The software used for this study was SPSS. Multinomial Logistic regression was used for statistical analysis of data to form a Tour Generation model.

4. RESULTS

The tour generation Model was developed by procuring data from different households using a questionnaire survey. The data was then processed to remove errors and inconsistencies. The data was digitized in Microsoft Excel and collated to get a travel schedule. Using statistical software, the data was processed to get a tour generation model by using binomial logistic regression. The significant variables are given in Table 3.

Table -3: Tour Generation Model

Sr. No	Tour Type	Variable	B	Sig.	Significance
1.	H_{Rec}	E_1	0.334	0.047	Significant
		D_2	-1.987	0.002	Significant
		D_4	1.498	0.043	Significant
2.	H_{edu}	C	2.081	0.000	Significant
		A	-3.815	0.048	Significant
		E_1	2.579	0.000	Significant

3.	H_{Shop}	D_4	2.687	0.031	Significant
7.	H_{work}	B	0.523	0.026	Significant
		D_4	1.572	0.017	Significant
		F_1	0.993	0.046	Significant

As shown in Table 3, for recreational tours the E1 is significant as younger people travel more and usually have fewer responsibilities to prohibit recreational activities. The HRec tours are negatively impacted by people in D2 as lower-income individuals tend to take part in fewer recreational activities. While it is positively impacted by D4, as higher-income individuals tend to take more recreational trips.

Educational tours are positively impacted by the number of children in a household. While it is negatively impacted by the number of members in a family as a whole. Larger families usually have problems providing for the family and thus it may affect the education of their children. The E1 also has a positive effect on the Hedu tours as people under the age of 30 are more likely to go to school/college.

D4 has a significant effect on Shopping tours as higher-income households tend to make more shopping trips.

Home-Work tours are affected by the number of working family members in a household. As more family members are working it leads to more tours generated. It is also positively affected by income group 4, as the higher-income populace tends to use their vehicles more and work far from home thus generating more tours. Vehicle ownership also affects the HWH tours as people who own vehicles are more likely to use them for work trips.

Using the above-mentioned coefficients and modifying them for per day per household. The model for tour generation will be:

The equation for the 'No. of HRecH Tours Per day Per household', 'No. of HScH Tours per day per Household', 'No. of HSH Tours per day per Household' and 'No of HWH Tours per day per Household' are stated respectively below:

$$H_{Rec} = 0.005955E_1 + 0.001152D_4 - 0.00887D_2 \quad (1)$$

$$H_{edu} = 0.00929C - 0.01703A + 0.011513E_1 \quad (2)$$

$$H_{shop} = 0.011996D_4 \quad (3)$$

$$H_{Work} = 0.0523B + 0.011161E_1 + 0.007018D_4 + 0.004433F_1 \quad (4)$$

By using these models for a test group of 30 households the number of tours came out to be 632 while the actual tours were 651.

Table -4: Tour Generation Projected vs Actual Tours Generated

Sr. No	Tour Types	Projected Tours	Actual Tours	Percentage Error
1.	H_{Rec}	41	45	8.89
2.	H_{edu}	259	252	2.70
3.	H_{Shop}	25	31	19.35
4.	H_{work}	307	298	2.93

5. CONCLUSIONS

In this study, we have developed an activity-based tour generation model. This model is validated and used to forecast travel behaviour. To validate the results, different aggregate statistics (Table 4) were calculated. Which closely correlates with the data collected from the field. The following conclusions are drawn:

- Lower income negatively impacts recreational tours. The lower the income, the lower the chance of the household undertaking recreational tours.
- The number of children positively impacts, while the number of family members negatively impacts the number of academic tours. A high number of family members may deter a household monetarily.
- The 'below 30' age group positively impacts the number of academic tours as people of that age are more likely to attend a school/college/university.
- The work-related tours are positively impacted by the number of working family members, higher income groups and vehicle ownership. As more family members work, more tours are generated. Similarly, people with higher incomes are more likely to travel for their jobs. Individuals owning a vehicle are more likely to choose the comfort of their car over public transport.

In the future, a more detailed study may be undertaken with more complex tour types. The tour types were limited in this study due to the small nature of the study and the small sample size. The sample size was small because of the conservative nature of the study area and the lack of resources in developing countries. More attributes may also be added such as distance from the workplace, traffic congestion, and inter-dependence between attributes for future research.

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