# The Use of Stated Preference Techniques for Modal Shift of Work Trip in Anand Agglomeration

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*Abstract—* Anand is one of the developing city in Gujarat state. Anand city is well known as milk city because of AMUL DAIRY, the world renowned organisation and it is also known as the milk capital of the India. Due to increasing vehicular growth vehicle in Anand, traffic congestion and environment pollution have been increasing day by day. The current study is to identify trip-influential parameters and their countermeasures to shift travel modes. The shift may be caused by a reduction in city bus travel time, increasing frequency and change in fare. The collection of data is conducted through revealed and stated preference surveys from city travellers of Anand Agglomeration. The demographic details play important role in mode choice behaviour and shift from existing mode in developing discrete choice models. The results are hoped to assist decision-makers on different levels to allocate resources wisely to public transportation improvement.

*Key words:* Discrete choice, binary logit, Revealed Preferences (RP), Stated Preferences (SP), Modal split, disaggregate travel demand, Modal Shift

## I. INTRODUCTION

Anand, a prosperous and economy-flourishing district, has a high private vehicle ownership that causes traffic problems. Public transport needs improvement in order to make the demand of this city. Intracity passenger transport is growing fast to meet demand for mobility. Anand railway station is the life line of rural peoples for their business, education and commercial activities. Anand, Vidhyanagar and Karamsad are famous for education hub so people are attracting toward Anand. Public transport is the safest modes in city. Various parameters such as fare, travel time, frequency, comfort, reliability, nearness to bus stop, and safety, have effect on mode choice. Modal split is the third phase of the four stage modelling; it is very important stage in travel demand modeling which leads to the decision of the infrastructure supply of any area.

## II. PROBLEM IDEFINITION

At Present Anand city is facing high urbanization and heavy economic growth. There is increasing demands for private and public transport in Anand agglomeration. To lead to the travel demand without increasing the congestion problem by personalised vehicles, there is a need for increasing the use of high occupancy modes. This problem needs to be addressed by understanding the behaviour of traveller's need and preferences of using the modes. For solving the congestion problem resulting from high vehicle ownership there is a need for improving the transportation planning in Anand city. Mode choice modeling, which is considered very essential for predicting the future growth for each mode and shift from one mode to another needs to be addressed by specifying and identifying the factors that contribute the use of different mode.

## III. OBJECTIVE OF STUDY

- To understand the factors affecting the mode choice.
- To estimate and calibrate the chosen mode choice model.

## IV. SCOPE OF STUDY

The study is focused on a potential travel mode shift from personal vehicle to safer modes of intercity public transport such as VTCOS. In order to encourage the shift, the potential factors that discourage personal vehicle use and incentives for using city public transport is required to be identified. By identifying and understanding the factors likely to encourage the shift, a model for mode selection can be developed. To understand the travel behaviour of road user, the data collection has been carried out in Anand agglomeration with specific emphasis on the trip made by different household in the area of Anand city, Gamdi, Jitodiya, Karamsad, Mogri, Vallabh Vidyanagar, Bakrol and Vithal Udyognagar. The data collection is having characteristics of sample representative of the population comprising of the above the study area.
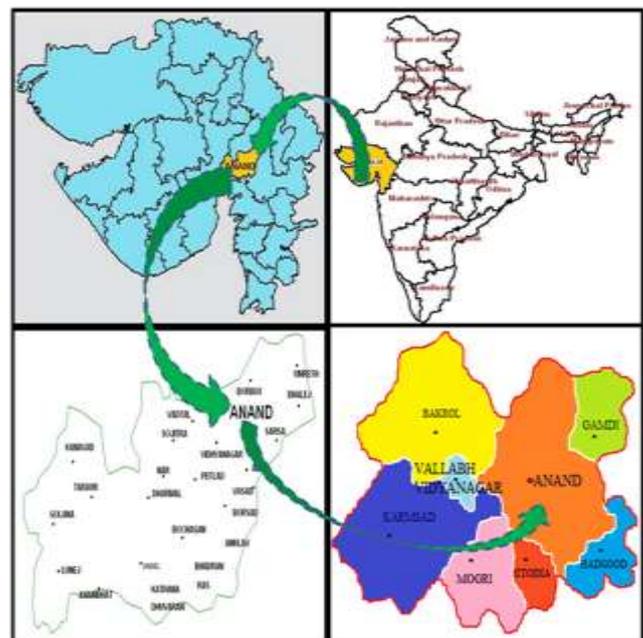
## V. STUDY AREA PROFILE



Fig. 1: Location map of Study area

Anand city is governed by Municipal Corporation which comes under Anand Metropolitan Region. The Anand city is located in Gujarat state of India. Anand Metropolitan Region covers the area of Anand city, Gamdi, Jitodiya, Karamsad, Mogri, Vallabh Vidyanagar, and Vithal Udyognagar which shown in Fig1. As per provisional reports of Census India, population of Anand in 2011 is 197,351; of which male and female are 102,359 and 94,992 respectively. Although Anand city has population of 197,351; its urban / metropolitan population is 286,921 of which 148,801 are males and 138,120 are females.

In education section, total literates in Anand city are 166,211 of which 88,444 are males while 77,767 are females. The sex ratio of Anand city is 928 per 1000 males. Child sex ratio of girls is 881 per 1000 boys. The child forms 10.13 % of total population of Anand City. As shown in Fig.2 the personalize vehicular population is increasing rapidly in last decade or so primarily due to rise in educational institutes in and around Anandcity.
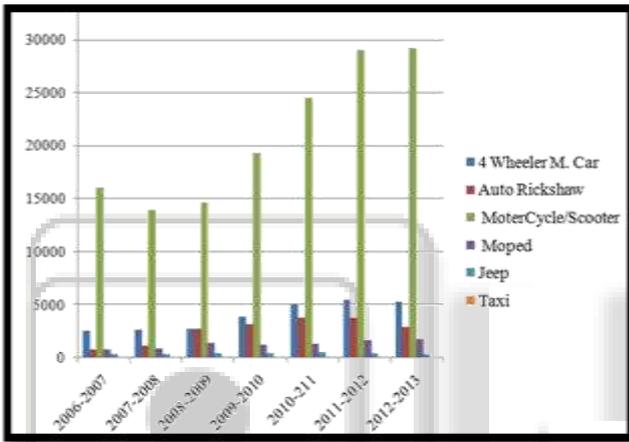

Fig. 2: Vehicular growth of Anand City

## VI. DESIGN OF QUESTIONNAIRE

The questionnaire was divided into two parts as can be seen below:
1) Part one: This includes the social and economical information about the respondents such as (gender, age, job, income, family size, ownership of private car, ownership of motorcycle, ownership of bicycle……etc)
2) Part two: This deals with the hypothetical choice of the respondents. The respondents were asked to rate his/her preferred modes among two different modes like personal vehicle and VTCOS according to two different choice set of attributes as shown in the sample table1.For collecting data this type of 16 choice set created with different value.

| Attributes | Option1 | Option2 |
|---|---|---|
| Mode For Travel | Personal Vehicle | VTCOS |
| Travel Time | Same | 25% More |
| Travel Cost | Same | 15% More |
| Comfort | Yes | Yes |
| Safety | Yes | Yes |

Table 1: Sample of choice set

## VII. SAMPLE SIZE DETERMINATION

Green (1991) recommended minimum sample size N for Multinomial logistic with N>50+8m where m is the number of predictors (factors). For twelve factors that affect the mode choice model in Anand city, the minimum sample size for this study is 146. For the purpose of this study 152 questionnaires were distributed for work trips. The random sample method was adopted in this study.

## VIII. ANALYSIS OF DATA RESULTS

The distribution of travelers for their gender is shown in table2. It is seen that 54.5% of the respondents are male and 45.5% are female.

The distribution of respondents' status is represented in Table2. The results show that about 40.3% of the respondents are worker, 27.4% are student, 27.6% are house wife, 2.8% are retired person, 1.9 % are not applicable.

The distribution of respondents' age is presented in Table2. As seen in the fig the large percent of workers lies in the age category from 15-30 and 30-50 years which represents about 37.9% and 32.8% of the whole sample respectively.

The distribution of respondents' average family monthly income is presented in Table: 2 The results reported in the Table2

| | | Frequency | Percent |
|---|---|---|---|
| GENDER | M | 316 | 54.5 |
| | F | 264 | 45.5 |
| STATUS | W | 234 | 40.3 |
| | S | 159 | 27.4 |
| | HW | 160 | 27.6 |
| | R | 16 | 2.8 |
| | NA | 11 | 1.9 |
| AGE (Year) | 0-15 | 50 | 8.6 |
| | 15 - 30 | 220 | 37.9 |
| | 30 - 50 | 190 | 32.8 |
| | 50 - 60 | 80 | 13.8 |
| | >60 | 40 | 6.9 |
| INCOME | <=6000 Rs | 26 | 4.5 |
| | 6000 - 15000 Rs | 241 | 41.6 |
| | 15000 - 40000 Rs | 201 | 34.7 |
| | 40000 - 60000 Rs | 52 | 9.0 |
| | >60000 Rs | 60 | 10.3 |
| FAMILY SIZE | 1 - 3 PERSON | 128 | 22.1 |
| | 3 - 5 PERSON | 422 | 72.8 |
| | 5 - 6 PERSON | 20 | 3.4 |
| | 7 - 8 PERSON | 10 | 1.7 |
| JD (journey distance0 | 0 - 1KM | 91 | 15.7 |
| | 1 - 3 KM | 77 | 13.3 |
| | 3 - 6 KM | 83 | 14.3 |
| | 6 - 10 KM | 43 | 7.4 |
| | 10 - 15 KM | 34 | 5.9 |
| | 15 - 20 KM | 12 | 2.1 |
| | NA | 240 | 41.4 |
| MODE | CAR | 35 | 6.0 |

| | | |
|---|---|---|
| 2 WHEELER | 215 | 37.1 |
| AUTO R | 175 | 30.2 |
| BUS | 39 | 6.7 |
| BICYCLE | 60 | 10.3 |
| WALKING | 41 | 7.1 |
| NA | 10 | 1.7 |
| SHARE | 5 | .9 |

Table 2:

Shows the majority of workers have a monthly income between 6000 – 15000Rs (41.55%) of the whole sample, while 15000 – 40000 Rs (34.66%)**.**

The distribution of respondents' family size is presented in Table:2. The collected data is categorized into four categories. The results reveals that the majority of employed people have a family size between 3-5 persons which represents about 72.76% of the whole sample, while the employed people with a family size between 7 - 8 persons represents only 1.72 % of the sample**.**

Table: 2 presented the distribution of transport means owned by the respondents. As seen in the table:2 about 60% of the respondents have a 2-wheeler, 27% of the respondents have bicycle, 11% have a car and the rest have no means of transport.

The distribution of trip length is shown in Table:2 The result shows that the majority of the sample has a trip length lies between 0 - 1 km which represents about 15.69% of the whole sample, while the trips which have a length 1 to 3 km has about 13.3% of the sample.

The trip which have a length between 3 – 6 km and more than 6km comes around 14.3% and 15.4% of the sample. The random movers in the Anand Agglomeration (41.38%) are the user who makes trips as per their work requirement.

The distribution of the various modes that are usually used by the respondents is reported in Table2. As seen in above table:2 the large percent of the respondents usually use the 2wheeler to their work or educational or other trip by 37.1% of the sample while the respondents usually use the AUTO R by 30.2% of the sample.

From the analysis that more priority is given to travel time (31.64%) and second priority is given to comfort (29.10%). The majority of respondent use petrol as fuel (Approximately 92.54%). From the study, it reveals that 44.22% respondents has to walk 0 – 0.5 km to reach the nearest bus stop and 30.64% respondents has to walk 1 - 2 km from their house.

From the analysis, it is seen that bus is a reliable service from the respondent point of view (63.95%) and bus is safe (47.83%). The 93.20% respondents said that bus is not expensive mode compare to other mode.

From the analysis that the females are likely to use the AUTO R (73.1%) and walking modes (58.5%) of transport more than the males do as the percent of the AUTO R (58.5%) and walking modes (41.5%) respectively. From the analysis, the percent of private car users in the age group between 30 to 50year (51.4%), while the 2 wheeler users in the age group between 15 to 30 year (47.4%). The old people prefer to have privacy and comfort in transport modes which are available in private car and large percent of 3 to 4 family size use personal vehicle.

From the analysis, the percent of travelers uses private car increases as the monthly income increases and the percent of riders using motorcycle and walking modes decreases as the monthly income increases. The large percent of private car and 2wheeler belong to worker category i.e. 82.9% and 59.1% respectively. This segment of society has high income to enable them to own their private vehicles. The large percent of bicycle users belongs to the student category (56.7%) and the considerable percent of bus and AUTO R users belongs to the category of house wife.

Non-auto modes (walking and bicycle) increases as the length of trip decreases while the using of auto modes (CAR, AUTOR, and 2-WHEELER) increases as the length of trip increases.

The large percent of AUTOR and walking users don't have their own means of transport while the large percent of private car, motorcycle and bicycle users have their own means of transport for work trip and educational trip.

## IX. CALIBRATION OF STATED PREFERENCE MODEL

The stated preference model was calibrated using the data collected from the answers of respondents from the questionnaire having different choice option. On the basis of data analysis there are two modes to be considered for modeling, which are personal vehicle and public transport (VTCOS) modes respectively.

| Variable | Description |
|---|---|
| TT | Total travel time in minutes (generic variable) |
| TC | Total travel cost in Rs (generic) |
| GEN | Gender of respondent ( I if male and 0 otherwise) |
| AGE | Age of respondent in years |
| INC | House hold monthly income in thousand |
| JD | Length of the trip in kilometres |
| NS | Nearest stop of bus in km |
| TTS | Time taken to reach nearest stop in min |
| WT | Waiting time for bus in min |
| Constant | Mode specific constant for work and educational trip |
| ASC1 | For personal vehicle (PV) |
| ASC2 | For public transport such as VTCOS (VT) |

Table 3: Abbreviation and description of explanatory Variable

| | Estimated Value | t-statistics |
|---|---|---|
| **Generic Parameters** | | |
| TT | -0.00852 | -0.66 |
| TC | -0.00852 | -3.18 |
| **Alternative Specific Parameters** | | |
| ASC2 | -0.123 | -1.99 |
| **Model Statistics** | | |
| Null log-likelihood | | |
| Init log-likelihood | -737.509 | |
| Final log-likelihood | -729.902 | |
| Likelihood ratio test | 15.214 | |
| Rho-square | 0.010 | |
| Adjusted rho-square | 0.006 | |
| Number of observations | 1365 | |
| Number of estimated parameters | 3 | |
| Iterations | 6 | |

Table 3: Estimation results of model 1

1)  Utility equation for Table 3

$$U_{(PV)} = \beta_1 *(TT_{PV}) + \beta2*(TC_{PV})$$
$$U_{(VT)} = ASC_{(PV)} + \beta1 *(TT_{VT}) + \beta2 *(TC_{VT})$$

| | Estimated Value | t-statistics | | t-statistics |
|---|---|---|---|---|
| **Generic Parameters** | | | | |
| TT | -0.0120 | -0.90 | | -2.34 |
| TC | -0.0116 | -3.28 | | -1.25 |
| **Alternative Specific Parameters** | | | | |
| ASC2(VTCOS) | 0.410 | 0.318 | | 1.71 |
| BETA3 (AGE) | -3.03e-014 | -0.0 | | -0.0 |
| BETA4 (GEN) | -4.98e-016 | -0.0 | | -0.0 |
| BETA5 (INC) | 2.51e-005 | 5.37 | | 3.04 |
| BETA6 ( JD) | -0.00869 | -1.04 | | 1.77 |
| BETA7(NS) | 0.0471 | 0.29 | | 0.19 |
| BETA8 (TTR) | -0.00681 | -0.45 | | -0.69 |
| BETA9 (WT) | -0.000784 | -0.05 | | -0.43 |
| **Model Statistics** | | | | |
| Null log-likelihood | | | | |
| Init log-likelihood | -737.509 | | | |
| Final log-likelihood | -729.645 | | | |
| Likelihood ratio test | 49.727 | | | |
| Rho-square | 0.034 | | | |
| Adjusted rho-square | 0.020 | | | |
| Number of observations | 1365 | | | |
| Number of estimated parameters | 10 | | | |
| Iterations | 84 | | | |

Table 4: Estimation results of model 2

2)  Utility equation for Table 4

$$U_{(PV)} = \beta_1 *(TT_{PV}) + \beta2*(TC_{PV}) + \beta3*(AGE_{PV}) + \beta4*(GEN_{PV}) + \beta5 * (INC_{PV}) + \beta6* (JD_{PV})$$
$$U_{(VT)} = CONSTANT + \beta1 *(TT_{VT}) + \beta2 *(TC_{VT}) + \beta3*(AGE_{VT}) + \beta4*(GEN_{VT}) + \beta7*(NS_{VT}) + \beta8 *(TTR_{VT}) + \beta9 *(WT_{VT})$$

3)  Utility equation for table 5

$$U_{(PV)} = \beta_1 *(TT_{PV}) + \beta2*(TC_{PV}) + \beta3*(AGE_{PV}) + \beta4*(GEN_{PV}) + \beta5*(INC_{PV}) + \beta6*(JD_{PV})$$
$$U_{(VT)} = CONSTANT + \beta1 *(TT_{VT}) + \beta2 *(TC_{VT}) + \beta7*(NS_{VT}) + \beta8 *(TTR_{VT}) + \beta9 *(WT_{VT})$$

| | Estimated Value | t-statistics | t-statistics |
|---|---|---|---|
| **Generic Parameters** | | | |
| TT | -0.0124 | -0.93 | -2.35 |
| TC | -0.0116 | -3.28 | -1.25 |
| **Alternative Specific Parameters** | | | |
| ASC2 | 0.349 | 0.79 | 1.34 |
| BETA3 (AGE) | 2.56e-005 | 5.39 | 2.98 |
| BETA4 (GEN) | -0.00924 | -1.10 | 1.73 |
| BETA5 (INC) | -0.00383 | -0.72 | -0.04 |
| BETA6 ( JD) | 0.102 | 0.52 | -0.41 |
| BETA7(NS) | 0.0191 | 0.11 | 0.12 |
| BETA8 (TTR) | -0.00484 | -0.31 | -0.74 |
| BETA9 (WT) | -0.000253 | -0.01 | -0.42 |
| **Model Statistics** | | | |
| Null log-likelihood | --737.509 | | |
| Init log-likelihood | -737.509 | | |
| Final log-likelihood | -712.266 | | |
| Likelihood ratio test | 50.485 | | |

| Rho-square | 0.034 | |
|---|---|---|
| Adjusted rho-square | 0.020 | |
| Number of observations | 1365 | |
| Number of estimated parameters | 10 | |
| Iterations | 78 | |

Table 5: Estimation results of model 3

From the various model with respect to the base model (Travel time and Travel cost is considered to be the Generic parameter), the forecasting in the models are improved by the addition of the parameters like Gender, Age, Income and journey distance etc. The internal sign for the different parameters are fulfilling the internal validity with exception of lower t statistics in some cases; this is due to the less no of samples as well as the lower variability in the data set as the city size is small for the discrete choice modeling.

## X.  MODEL VALIDATION

The validation procedure is essentially a process of ensuring that the choices observed in a set of individuals are consistent with the probabilities predicted for the same set of individuals by the model. To complete the above analysis, 119 observations are taken for validation, while the remaining observations are used for the parameter estimation.

| S. No | Choice | Actual Choices | Actual Shares (%) | Predicted Choices | Predicted shares (%) | Percent correctly predicted |
|---|---|---|---|---|---|---|
| 1 | PERSONAL VEHICLE | 63 | 52.94 | 76.35 | 67.56 | More than 100% |
| 2 | VTCOS | 56 | 47.05 | 36.65 | 32.43 | 68.9% |
| | Sum | 119 | 100 | 119 | 100 | |

Table 6:  Prediction performance of model on validation

The results of the validation process are shown in Tables 6 the results show that the predicted and the observed shares are matching with reasonable accuracy. For increasing the accuracy between actual and predicted value of the choices it is required to incorporate other variables, which are more vital in the decision, making of the choices.

## XI.  CONCLUSIONS

1)  Based on the descriptive analysis of the data, the ownership of vehicle, trip length, age, monthly income and gender can be considered as the most important factors that affect the mode choice, while family size and status seem to have low effects on choice decision of travelers.
2)  From the model, the total travel time, income, gender, age, nearest stop, time taken to reach, waiting time and journey distance are the factors that affect the mode choice for the group belongs to people going for work in Anand agglomeration.

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