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Mode Shift Analysis for Industrial Workers- A Case Study of Two Industrial Zones (GIDC Makkarpura and Por- Vadodara)

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Abstract

One of the major traffic problems these days is the increased traffic volume, which has resulted into increased traffic congestion. As known, the work trips are the daily trips, having a higher frequency than other trips. GIDC Makkarpura and GIDC Por are two major industrial zones located in the Vadodara city, where a large amount of working trips of the city are concentrated. Analysing the possible mode choice and mode shift in the selected zones can lead to a considerable shift of the private vehicle users to the public mode of transportation, to reduce the congestion. Taking into consideration the major factors responsible for the mode choice, a questionnaire has been designed into 2 parts for RP & SP survey. Based on the observations, 8 different binary logit models have been worked out for varying conditions of travel time, travel cost, comfort and safety of the modes. The utility of the models shall be worked out using the Biogeme software, to choose the best possible modifications to be brought in the public mode attributes to encourage more use for the same. 16 different choice sets for comparison between the private and the public modes have been framed for the purpose of SP survey. The demand of the industrial workers for their work trips will also be considered; and the necessary improvements in the existing travel services will be suggested to encourage the use of public mode of travel in the city.

Keywords: Mode choice, Work trips, SP (Stated Preference), RP (Revealed Preference), Utility Maximization, Mode attributes, Choice Sets, Binary logit model.

1. Introduction

To a decision maker i.e. the road user, various modes for travel are available for the choice, such as walk, car, bus, railways etc. Each mode has different attributes associated with them, such as difference in the travel time, travel cost, safety, comfort, reliability, accessibility, convenience, capacity, speed, fuel consumption etc. The trip attributes such as the destination zone, origin zone, travel distance, trip purpose etc. also vary. Thus there can be high variability in choosing a particular mode of travel by a road user. Apart from these factors, the socio-economic characteristics of each individual such as the household income, cars owned, number of members in the family, number of earning members etc. also differ, which is again an important deciding factor for the mode choice.

The traffic congestion has also increased greatly in past few decades, one of the efficient ways to overcome the problem is to shift the focus of travel onto the public modes of transport. Thus mode choice or mode shift analysis for the major frequency work trips can prove to be an efficient solution to the problems faced.

2. Literature Review:

Now- a days traffic congestion is a major issue of concern for the transportation planners. The analysis of the mode choice by the decision makers is broadly studied to analyse, design, and implement efficient modes of transportation to meet the travel demand and to overcome the traffic problems.

Few of the relevant studies are as follows:

R. Ashalatha; V. S. Manju; and Arun Baby Zacharia (2013), used multinominal logistic

regression method to carry out the mode choice analysis in the city of Thiruvananthapuram. It was observed that preference to car against public transport increases with increase in age, travel time and cost.

Zhi-jian Chen, Lin Cheng, Hu-nan Deng, and Jing-ke Zhang (2010), compared the current scenario of the travel pattern in the Nanjing city and also analyzed the effect of the proposed MNL. In this study the multicollinearity amongst the explanatory variables was overcome by classifying them depending upon their correlation. The ones with high dependence were chosen for the analysis of mode choice and the model was developed. The proposed model proved to be efficient in reducing the multicollinearity between the variables and improved the Macfadden coefficient.

Yoshitaka kajita, Takeshichishaki (2002), collected the person trip data and designed different choice sets to analyse the existing mode choice in the chosen zone. They even introduced the importance of the users' consciousness in designing the mode choice model. Disaggregated binary logit model was framed which had a multiple correlation coefficient of 0.5-0.6, i.e. the designed model was efficient.

Huanhuan Yin, Hongzhi Guan, Tong Liu, Liyuan Gong, and Juan Li (2010), designed a MNL model after analysing the Urban mode choice behaviour in the Jinan city and through the model, they concluded that there was a stable relationship between the personal, family and trip characteristics. With suggested improvements and adjustments, the Urban mode choice was optimized.

Zhou Gaowei (2010), studied the multiple factors and the passengers' heterogeneity involved in the intercity passengers' mode choice. The best developed model was then chosen based on the utility maximization theory, for the efficient intercity transportation corridor.

Miaomiao Zhou and Jian Lu (2011), developed MNL and probabilistic neural model to determine the probability of all trip mode choice. It was concluded that probability model is more efficient than MNL to predict the mode choice of the urban residents.

Kaori Mizutani and Takamasa Akiyama (2000), used the fuzzy logic to develop the logit model. The parameters were determined using maximum likelihood solutions through trial and error. The linear utility functions were used to describe the average behaviour.

Ahmed Hamdy Ghareib (2015), made a comparison between the logit & the probit model for the mode choice, and determined that logit is more analytical whereas probit has more reliable theoretical basis.

Al Ahmadi (2006), determined that factors such as travel time, travel cost, travel distance, carpool members, monthly income, the nationality of rider, and cars owned were the important factors for determining the intercity mode choice Pattern.

Abdullah Nurdden, Riza Atiq O.K.Rahmat and Amiruddin ismail (2007), compared the utility of private (car) and public mode of transport, and determined that reduction of travel time, travel cost and distance of public transport from house can encourage the choice of public transport over the private mode of travel. Out of all the factors studied, the travel time and travel cost were major factors which lead to the choice of car over public transit.

3. Study area profile:

3.1 GIDC Makkarpura: is an industrial estate developed under the Gujarat Industrial Development Act 1962 for industrial acceleration. It is located to the east of Vadodara city, and is divided into following sectors:

A1-A3
B1-B7
C1-C5
D1-D3

Depending upon the type and size of the industries. It comprises of the highest number of work trips of the city concentrated there.

3.2 GIDC por: is situated on the NH8. It has 511 number of plots over an area of 134 hector and has 7kms of internal roads.

3.3 The layout maps for both the selected zones are as shown:

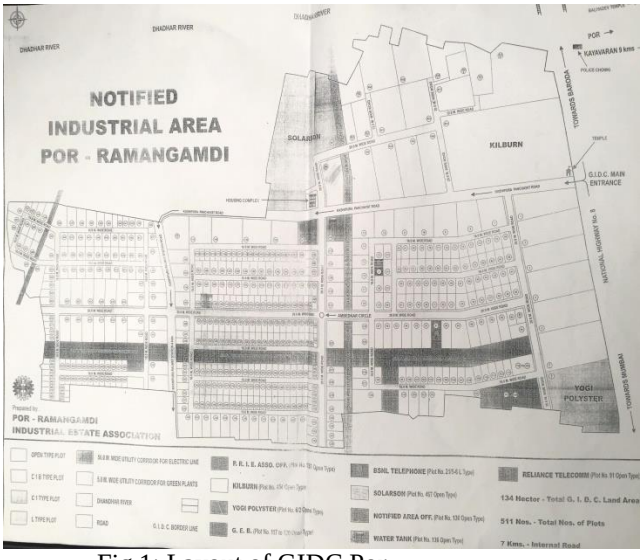

Fig 1: Layout of GIDC Por

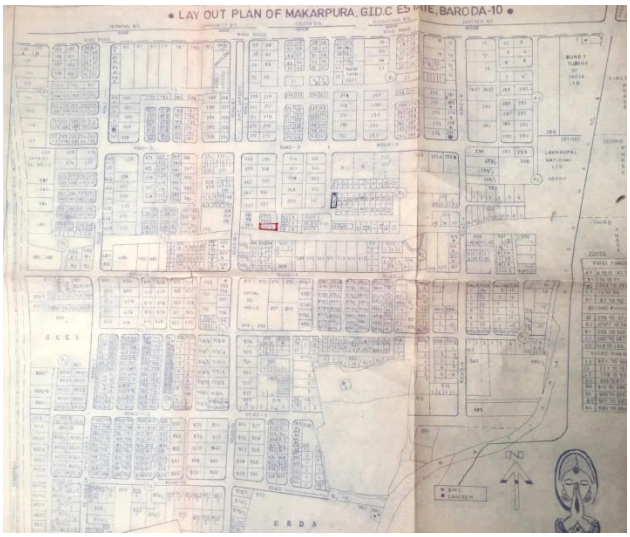

Fig 2: Layout of GIDC Makkarpua

4. Methodology:

To analyse the mode shift in the chosen zones. RP and SP survey forms have been designed, considering all the factors that are likely to affect the mode choice.

Part one of the questionnaire comprises of 12 different factors which include socio-economic characteristics such as income, family size, car ownership, age etc. Trip characteristics such as travel time, travel cost, fuel consumption etc. And the opinion details for the existing public transport facilities such as travel time, cost, safety, comfort, reliability, accessibility etc.

Part two is designed to carry out the stated preference survey. For this, 16 different choice sets between the private vehicle and public mode (VTCOS) have been designed. Each of the set has varying conditions of the travel time, travel cost, safety and comfort, from which the decision maker has to make a choice.

The sample size is decided based on the condition that N > 50 + 8m; where m is the number of characteristics. Here m being 12; the effective sample size is 146. The sample size chosen for the pilot survey is 20, with an objective to determine the completeness of the designed questionnaire.

Based on the results obtained, 8 different models have been designed for the validation and calibration using the Biogeme software. The designed models are as shown below:

1. Base model

$U_{(PV, VT)} = ASC_{(PV, VT)} + \beta_1^* (\text{Travel time}_{(PV, VT)}) + \beta_2^* (\text{Travel cost}_{(PV, VT)})$

2. Model 1

$U_{(PV, VT)} = ASC_{(PV, VT)} + \beta_1^* (\text{Travel time}_{(PV, VT)}) + \beta_2^* (\text{Travel cost}_{(PV, VT)}) + \beta_3^* (\text{Income}_{(PV, VT)})$

3. Model 2

$U_{(PV, VT)} = ASC_{(PV, VT)} + \beta_1^* (\text{Travel time}_{(PV, VT)}) + \beta_2^* (\text{Travel cost}_{(PV, VT)}) + \beta_{31}^* (\text{Income}_{(PV)}) + \beta_{32}^* (\text{Income}_{(VT)})$

4. Model 3

$U_{(PV, VT)} = ASC_{(PV, VT)} + \beta_1^* (\text{Travel time}_{(PV, VT)}) + \beta_2^* (\text{Travel cost}_{(PV, VT)}) + \beta_3^* (\text{Journey distance}_{(PV, VT)})$

5. Model 4

$U_{(PV, VT)} = ASC_{(PV, VT)} + \beta_1^* (\text{Travel time}_{(PV, VT)}) + \beta_2^* (\text{Travel cost}_{(PV, VT)}) + \beta_3^* (\text{Income}_{(PV,VT)}) + \beta_4^* (\text{Journey distance}_{(PV, VT)})$

6. Model 5

$U_{(PV, VT)} = ASC_{(PV, VT)} + \beta_1^* (\text{Travel time}_{(PV, VT)}) + \beta_2^* (\text{Travel cost}_{(PV, VT)}) + \beta_{31}^* (\text{Income}_{(PV)}) + \beta_{32}^* (\text{Income}_{(VT)}) + \beta_{41}^* (\text{Journey distance}_{(PV,)}) + \beta_{42}^* (\text{Journey distance}_{(VT)})$

7. Model 6

$U_{(PV, VT)} = ASC_{(PV, VT)} + \beta_1^* (\text{Travel time}_{(PV, VT)}) + \beta_2^* (\text{Travel cost}_{(PV, VT)}) + \beta_3^* (\text{Nearest bus stop}_{(PV, VT)})$

8. Model 7

$U_{(PV, VT)} = ASC_{(PV, VT)} + \beta_1^* (\text{Travel time}_{(PV, VT)}) + \beta_2^* (\text{Travel cost}_{(PV, VT)}) + \beta_3^* (\text{Income}_{(PV, VT)}) + \beta_4^* (\text{Journey distance}_{(PV,VT)}) + \beta_5^* (\text{Nearest bus stop}_{(PV,VT)}) + \beta_6^* (\text{Time taken to reach}_{(PV, VT)}) + \beta_7^* (\text{Waiting time}_{(PV, VT)})$

9. Model 8

$U_{(PV, VT)} = ASC_{(PV, VT)} + \beta_1^* (\text{Travel time}_{(PV, VT)}) + \beta_2^* (\text{Travel cost}_{(PV, VT)}) + \beta_3^* (\text{Nearest bus stop}_{(PV, VT)}) + \beta_4^* (\text{Time taken to reach}_{(PV, VT)}) + \beta_5^* (\text{Waiting time}_{(PV, VT)})$

About 1/10 of the data is to be selected for the model validation whereas the remaining 9/10 data is for the calibration of the model.

The model calibration for determining the t-test results, log likelihood value, maximum log likelihood, goodness of fit index i.e. rho-square and

the corrected goodness of fit index rho-bar square has been computed using the Biogeme software.

The various choice sets designed for the stated preference survey are as follows:

Table 1: choice set A

attributes	Option 1	Option 2
mode for travel	personal vehicle	vtcos
travel time	same	25% more
travel cost	same	15% more
comfort	yes	yes
safety	yes	yes

attributes	Option 1	Option 2
mode for travel	personal vehicle	vtcos
travel time	same	25% less
travel cost	same	15% more
comfort	yes	yes
safety	no	yes

attributes	option 1	option 2
mode for travel	personal vehicle	vtcos
travel time	same	25% more
travel cost	same	30% less
comfort	no	no
safety	yes	yes

attributes	option 1	option 2
mode for travel	personal vehicle	Vtcos
travel time	same	25% less
travel cost	same	30% less
comfort	yes	No
safety	yes	no

attributes	option 1	option 2
mode for travel	personal vehicle	vtcos
travel time	same	25% less
travel cost	same	15% less
comfort	no	no
safety	no	no

attributes	option 1	option 2
mode for travel	personal vehicle	vtcos
travel time	same	25% more
travel cost	same	15% more
comfort	yes	yes
safety	no	yes

attributes	option 1	option 2
mode for travel	personal vehicle	vtcos
travel time	same	25% more
travel cost	same	15% more
comfort	yes	yes
safety	yes	yes

attributes	option 1	option 2
mode for travel	personal vehicle	vtcos
travel time	same	25% less
travel cost	same	15% more
comfort	yes	yes
safety	yes	yes

Table 2: choice set B

attributes	Option 1	option 2
mode for travel	personal vehicle	vtcos
travel time	same	25% less
travel cost	same	15% more
comfort	yes	no
safety	yes	no

attributes	option 1	option 2
mode for travel	personal vehicle	vtcos
travel time	same	25% more
travel cost	same	15% more
comfort	no	yes
safety	no	yes

attributes	option 1	option 2
mode for travel	personal vehicle	vtcos
travel time	same	25% more
travel cost	same	15% less
comfort	no	no
safety	yes	no

attributes	option 1	option 2
mode for travel	personal vehicle	vtcos
travel time	same	25% less
travel cost	same	15% less
comfort	yes	yes
safety	yes	yes

attributes	option 1	option 2
mode for travel	personal vehicle	vtcos
travel time	same	25% less
travel cost	same	30% more
comfort	no	no
safety	yes	yes

attributes	option 1	option 2
mode for travel	personal vehicle	vtcos
travel time	same	25% more
travel cost	same	30% more
comfort	yes	no
safety	yes	no

attributes	option 1	option 2
mode for travel	personal vehicle	vtcos
travel time	same	25% more
travel cost	same	30% less
comfort	no	no
safety	no	no

attributes	option 1	option 2
mode for travel	personal vehicle	vtcos
travel time	same	25% less
travel cost	same	30% less
comfort	yes	yes
safety	no	yes

The results from the stated and revealed preference survey have been obtained using the designed questionnaire and the given choice sets for the following number of respondents, number of observations and the number of parameters for the designed models of utility. The analysis of which has been done in the Biogeme software in order to

arrive to the conclusion of the pilot survey.

Table 3: Number of observations for pilot survey

Variables	Constant model	Base model	Model 1	Model 2	Model 3	Model 4	Mode l 5	Model 6	Model 7	Model 8
No. of respondents	40	40	40	40	40	40	40	40	40	40
No. of observations	320	320	320	320	320	320	320	320	320	320
No. of parameters	1	3	4	5	4	5	7	4	8	6

Few factors affecting mode choice, respondents ready to use public transport, if frequency is improved and the best and worst aspect of public transport is given in Fig 3 to Fig 6.

The travel time and travel cost, are major parameters affecting mode choice. The best aspect of public transport is to save money, and time; while worst aspects are no seats and discomfort to users. The respondents read to use the improved public transport are 77%

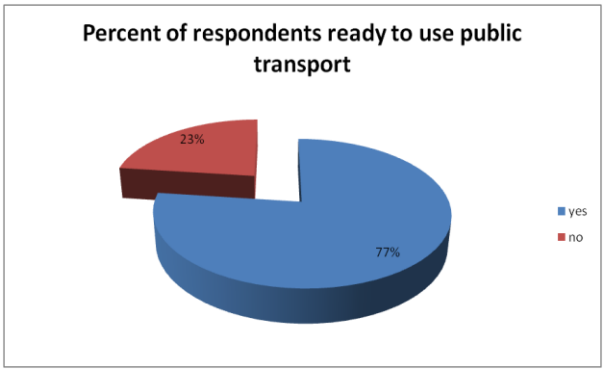

Fig 3: Respondents ready to use public transport, if the frequency is improved.

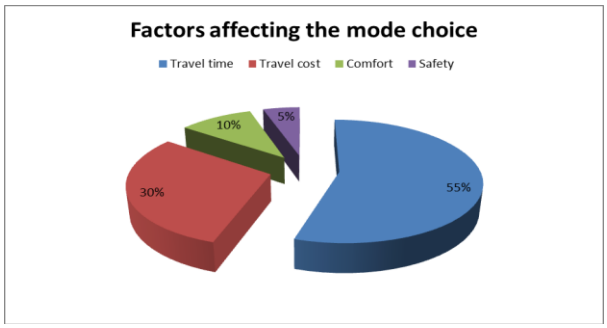

Fig 4: Factors affecting the mode choice

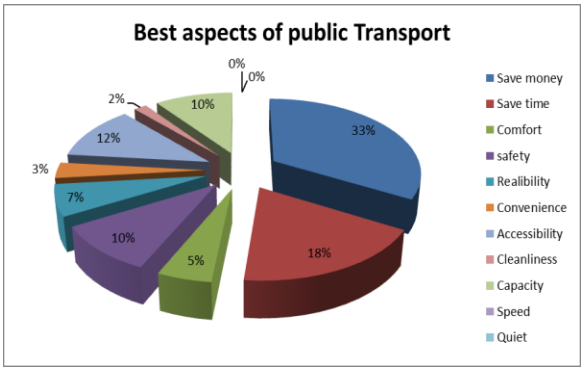

Fig 5: Best aspects of public transport

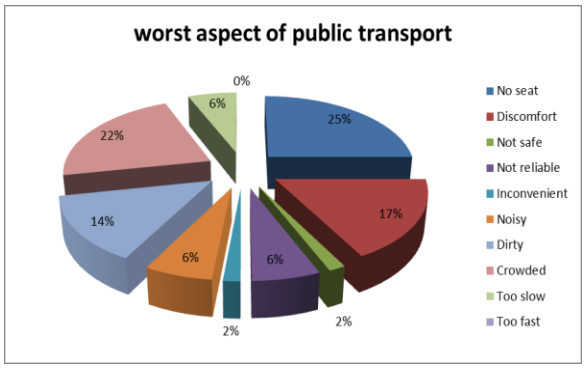

Fig 6: Worst aspects of public transport

5. Conclusion

From the RP and SP survey carried out for the chosen sample , following conclusions are drawn:

- From the calibration of the models by Biogeme software, the utility function calculated with the base model (travel time and travel cost), it is found that travel time and travel cost has negative sign which fulfil internal validity.
- Moreover the income parameter, which is also considered in the subsequent model also received the positive sign, which also fulfils the internal validity.
- The impact of the other parameters in the pilot study, though fulfil the internal validity, the external validity that is rho-square value is not improved at the same pace.
- The reason behind this is the small sample size of pilot study.
- The main survey which is to be carried out whose analysis is to be done, may reflect the above requirements as the sample size is bigger as well as it also covers different factors and different segments of the selected industrial zone.

- However, from the pilot survey it can be concluded that the completeness of the questionnaire is efficiently satisfied and the same designed questionnaire and choice sets can be used for the main survey.

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