2014•2015
SCHOOL FOR TRANSPORTATION SCIENCES
Master of Transportation Sciences

Master's thesis

Analysis of Value of Time (VoT) and Mode Choice among various regions; A case study for Karachi City

Supervisor :
Prof. dr. Davy JANSSENS

Syed Baqueri
Thesis presented in fulfillment of the requirements for the degree of Master of Transportation Sciences

Universiteit Hasselt | Campus Hasselt | Martelarenlaan 42 | BE-3500 Hasselt
Universiteit Hasselt | Campus Diepenbeek | Agoralaan Gebouw D | BE-3590 Diepenbeek

2014•2015
SCHOOL FOR TRANSPORTATION SCIENCES
Master of Transportation Sciences

Master's thesis

Analysis of Value of Time (VoT) and Mode Choice among various regions; A case study for Karachi City

Supervisor :
Prof. dr. Davy JANSSENS

Syed Baqueri
Thesis presented in fulfillment of the requirements for the degree of Master of Transportation Sciences

universiteit hasselt
KNOWLEDGE IN ACTION

Preface

This report is the outcome of Master Thesis which is an integral part of Transportation Sciences Master's program at Hasselt University. I proposed this topic myself for few reasons. First, I had interest in studying Value of Travel Time since I came across this notion. Secondly, such a study can provide profound assistance in transportation planning in my home country Pakistan. I have enjoyed the work and I am confidently looking forward to continue it afterwards where necessary.

I would like to thank my promotor Prof. Davy Janssens whose thoughts and guidance during research setup were most imminent contribution in this project. I am also obliged to my supervisor Wim Ectors for his inspirational assistance at each and every step of this project. His detailed comments, reviews and feedback allowed me to reach my goal in time. Moreover, his exceptional contribution were also present in the paper (accepted at Urban Transport Conference, Weesex 2015) written from this master thesis. I am also grateful to Sung Jin Cho and Won do Lee who arranged reference material for this research.

I would also like to thank Prof. Mir Shabbar Ali for allowing me to use the Toyota-Research on Traffic Congestion (TRTC) data for this study. Moreover, his support for distributing the questionnaire survey is also significant. I am also thankful to Mr. Ashar Lodi for allowing me to use HIS 2010 data. I am also beholden to Mr. Muhammad Ahmed for promptly providing me the GIS files of Karachi. My acknowledgements to all respondents who answered the questionnaire survey during their valuable time. Further I would also like to thank my family members. Their patience was noteworthy to let me focus on my thesis work.

Syed Fazal Abbas Baqueri

June 2015

Summary

Value of Time studies aim to assist transport policies and projects. This subject has been widely researched in last few decade. Rich literature covering data collection, model estimation and results acceptability has already been penned down. However, in developing countries VOT studies are less covered due to their multifaceted dimensions. This study aims to estimate and compare VOT for regions having disparate economic and socioeconomic conditions.

Traffic congestion in mega cities is a common phenomenon for developing countries. Numerous studies on congestion cost estimation have been conducted which aims to quantify its monetary losses. Correspondingly, applications of choice models and Value of Time (VOT) assessments through utility maximizing theory are abundantly available in transport literature. However, estimating VOT on congested route for work trips certainly has some gaps to be filled. To recognize the difference under normal and congested network, the current study focuses on VOT estimation for work trips under an extremely congested network.

As perceived, results revealed strong impact of travel time and travel cost on (dis)utility of travel. However, their impact was much stronger as compared to other studies. This study attempted to distinguish VOT parameters with regional attributes and economic conditions. These results can be utilized by policy makers to reduce congestion, monetary and time losses through efficient transport planning.

To compare the results for congested region, Mode Choice models (based on HIS 2010 data) for Karachi City are also developed in this study. These models were developed at Town level and for different trip purposes. The heterogeneous traffic in Karachi city made these models stimulating. Distinguished travel behaviour was observed for different Towns. The results revealed dissimilar relevance for each travel mode with town and travel purpose.

GIS models were also developed from the results obtained from choice models. These models were used for understanding the relationship between mode preference and spatial characteristics.

A stated preference survey was also designed for estimating Value of Time. The results obtained from this survey were compared with results obtained from mode choice. The comparison provided similarity between both results to a high level. However, the limitation

This study provided vision as how travelers value their travel time. It shows vast differences at town level, activity purpose and travel mode. The results obtained from this study further calls for research in this dimension. It also provides some useful insights for transport policy.

Table of Contents

List of Figures

List of Tables

Chapter 1: The problem description

1.1 Introduction

Travel time is most imperative attribute that commuters take into account during their journey. Commuters assign a value to their time based on their socioeconomic profile and trip attributes. Therefore, the Value of Time (VOT) Estimation is widely used in transport investments projects in their cost-benefit analysis. Although, common in developed countries, less literature is available on VOT estimation for least developed countries (Lioukas, 1982).

> "Time is more valuable than money. You can get more money, but you cannot get more time." Jim Rohn

Travel is usually considered as a derived demand (Patricia L., 2001). In order to perform a certain activity, a commuter chooses the most optimal route based on available sets of Travel Time (TT), Travel Cost (TC) and other personal characteristics. The significance of these attributes varies from person to person. However, the route having maximum 'utility' is selected. This utility is referred as the perceived ability of something to satisfy needs (Marshall, 1920).

A lot of research has been done in defining this utility through many approaches. However, there remains a difference in actual values and those perceived by commuters. There are several reasons of this difference. For instance consider travel time: for a regular trip, the travel time stated by the respondents is the result of personal scheming, which in reality can be different than stated. Therefore, in such studies, personal observance plays an important role.

Further ahead, in optimizing the utility each individual has their own constraints. These constraints demand the VOT estimation at disaggregate level, as each individual has its own constraints. The most common constraints include the Wage Rate, travel budget etc. This makes the VOT estimation game more interesting as there lies a cut-off point to enhance each attribute. Although money can be invested more, time however cannot be purchased (can only be utilized in some other activity) and is entitled as a limited commodity. This paradigm reflects a well-known concept known as Willingness to Pay (WTP). Value of time estimates the alacrity of persons to pay for each unit of time.

Various researches have been conducted under this domain. They cover parameters affecting VOT, their estimation and their reliability measures. Adequate research has already been conducted in more developed countries however less literature is available for Least Economically Developed Countries (LEDC).

Many studies show that there is a strong relationship between employment place and its commuting options (Shen, 1998), (Vega, 2012). However, due to poverty in mega cities of less developed countries, a huge percent of inhabitants have to cover a vast distance to earn their living.

VOT studies have mostly been used in cost benefit analyses and applications of new transport policies and modes. A vast range of data collection technique such as Stated Preference and Revealed Preference have been introduced and utilized to much extent in VOT studies. Additionally, valuation practices such as utility theory and prospect theory demonstrate the advancements, continuous research and productivity in this area.

For less developed countries, where there is less or no indication of work trip patterns and their economic appraisals, vehicle operating cost (VOC) has been used as most valid predictor in its absence. Besides, the working times are irregular and vary drastically on daily wage and other factors. Therefore, public investors are more inclined to fund infrastructure projects than essentially estimating Value of Travel Time Savings (VTTS) for rural areas. This is because that most transport is conducted through non-motorized modes.

Previous milestones achieved by researchers contain VOT estimation models for developed and less developed areas and urban and rural phenomena. Yet, there isn't a lot of research available for VOT on congested networks. However, they are calculated with respect to purpose of journey, travel mode and even time of day. This research aims to mitigate the hiatus present in this field by estimating Value of Time for congested region.

1.2 Purpose

This research aims to estimate the variations in value of time in a region with respect to socioeconomic conditions. To achieve this aim, the research was divided into two broad portions. The first dealt with estimating value of time for a region having high traffic congestion while the other part of this research was to develop choice models based on the travel time. This will lead to estimate the relevance of transport mode associated with travel time. Karachi, being a mega city and having diverse socioeconomic regions was selected as the study area.

The first study area is an industrial stretch in Karachi. It connects the city with Port Qasim Industrial Area and hence is a carrier for work based trips. The details of this area are explained in the third chapter of this report. The data used for this research was acquired from NED University of Engineering and Technology, collected for the Toyota Research on Traffic Congestion (T-RTC) project funded by Indus Motor Company.

The output of this is the basis for VOT estimation for a distinct scenario occurring at a regular basis i.e. congested road. Because few literature is available in this specific field, a novel work in this area could have a significant impact. Previous researchers have just mentioned the fact that VOT can upsurge in traffic congestion (Gwilliam, 1997). Further ahead, the comparison analysis of economy with disaggregate VOT will provide a novel length to studies in this field and other transport policies.

This research will directly benefit transport improvement projects for congested networks. It can define the project feasibility based on monetary gains of Travel Time savings. It will also enable to set path for calculating VOT for similar settings. It will cover statistical methods which have been used for VOT estimation and also comment on values obtained.

The second focus of this study was the development of mode choice models. These choice models were developed for complete city and, as perceived, unalike results were obtained for different Towns. FIGURE 1 explains the scope of this project.

A comprehensive questionnaire survey was also developed that focused on value of time estimation. The survey was designed keeping in view followings aims:

1. Design a questionnaire survey that should take into account all factors that affect travel likings.
2. Distinguish travelling preference between employed and unemployed persons for various trip purposes.
3. Design an optimal SP surveys that should be capable to determine value of time.

1.3 Objectives

The concrete objectives of this research are to:

1. Analyze effects of socio-demographic and travel parameters on commuters VOT.
2. Estimate Value of Time for congested region.
3. Analyze the dependency of VOT on region economy.
4. Evaluate the effect of mode on VOT.

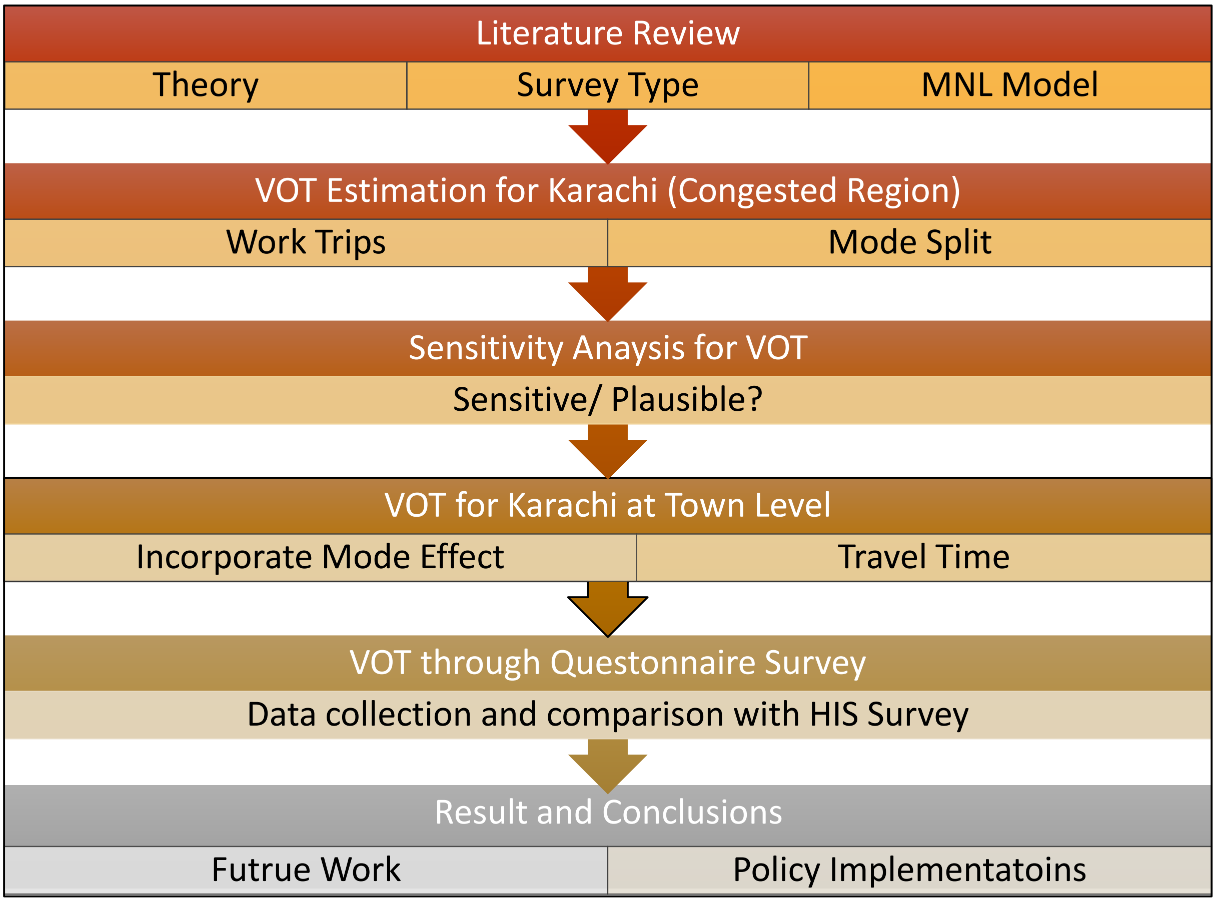

FIGURE 1 Scope of Work.

1.4 Way forwards

The next section of this report shows the details of previous research in this domain. It explains the evolution of VOT and comments on its development from initial concepts, and current practices. Chapter 3 of this report enlightens the VOT for region having high traffic congestion; analyzed as part of this project. It explains the details of the study area and data. Furthermore, the analysis used for the VOT estimation, followed by its results are part of this chapter. Chapter 4 describes the mode choice models for Karachi at town level. These models incorporated the effect of trip purpose, travel mode for travel time. In Chapter 5 GIS maps are illustrated along with a brief discussion on them. The development of questionnaire survey and its analysis is discussed in Chapter 6. The last chapter of this report contains the conclusion, recommendation and future work.

Chapter 2: Literature review

2.1 Introduction

The concept of Value of Time (VOT) was first introduced by Becker when he proposed the conversion of time into money by assigning more time to work (Becker, 1965). It also set the basis of the 'wage rate' approach. VOT was distinguished into two main categories i.e. work and non-work trips. Hence, the value of 'time saved' was weighted equal to 'non-work' time. Oort proposed some modifications in this concept. He incorporated travel time in the Utility and sets two motives of travel time savings (Oort, 1969). The first was in the form of additional time allotted to work. The second was the reduction in stress due to reduced travel. The theory calculated VOT from only work and non-work happenings. De Serpa classified VOT into three main effects as a function of income, activity and Value of Time Savings (VTS) (De Serpa, 1971). Jara Diaz (Jara-Diaz, 2003) studied if the time saved can be used in another activity while Small conversed the option of rescheduling activity given a schedule (Small, 1982).

There is a rich literature available in valuing travel time savings. They are broadly divided into two components representing user dimensions (age, income, job status etc.) and measurements related to mode choice (travel time, comfort, safety etc.) (Wardman, 2004). Value of travel time savings (VTTS) differs between modes, because of both mode and user characteristics (Flügel, 2014), (Fosgerau M., 2006). Within the mode attributes, VTTS can also vary with passenger and freight transport. (VPTI, 2013).

A lot of research has been carried out that ascertains the impact of travel purpose in estimating value of travel time. Many researchers including (Belenky, Revised Departmental Guidance on Valuation of Travel, 2011), (CHEN Xumei, 2011), (Camille Kamga, 2014), (Meilan Jiang, 2004) and (Fangshu Lei, 2014) worked on differentiating value of travel time with trip purpose. Amongst them, and as per intuition, the highest value of travel time is attached with work/ business trips.

Value of time has also been studied for Least Developed Countries (LDC). An example is one particular study carried out in Bangladesh (Farhad Ahmed K. G., 2004). This study adopted the concept of work and non-work activities for its research. It focused that the 'western concept of VOT' cannot be directly applied to LDC. However, in a Stated Preference (SP) survey the VOT was found to be 0.14$ for rural area in Bangladesh. He further explained that the western concept cannot be directly applied due to informal employment and thus the dividing time into work and non-work time is not straight forward anymore.

The next section explains the general concepts of VOT used in scientific research. It explains the parameters associated in its calculation and their significance, along with all the methods used for VOT derivation.

2.2 General Concept

Travel is generally treated as a 'derived demand'. This statement employs that the main aim to travel is to accomplish activities. Activities here refers to a huge domain which comprises of work, business, social, leisure and other tasks. Therefore, in general the utility of travel time is itself negative (Belenky, The Value of Travel Time Savings: Departmental Guidance for Conducting Economic Evaluations, 2011). This negative utility denotes that an increase in travel time will reduce the motivation to commence trips and vice versa. It also employs to the 'willingness to pay' of commuters in order to reduce travel time, but it is hereby important to consider that the time saved is used in another activity (for instance arriving early at work).

Wardman also studied effect of 'trip distance' on VOT and determined that VOT increases with increase in distance (Wardman, 1998). He further demonstrated that time spend during traffic congestion can be as high as 70% as In-Vehicle Time (IVT). The research also indicated that 'late time' can be used as a good estimate in replacement of travel time's standard deviation (Pedro A.L. Abrantes, 2010).

From the above set basis, the main step is to formulate the value of time savings itself i.e. the unit amount a person is willing to spend to save one unit of time. This depends on the commuter's personal attributes such as capacity to spend (represented as a factor of wage rate) and trip conditions such as purpose, mode, length and time of day. Amongst them, the most commonly analyzed trips are work trips as they have the largest share in daily trips. Because of the abundant availability of studies the results are laudable and cogent to a high degree. However, the reliability of VOT estimations are further discussed in this report. The parameters associated with VOT estimation are discussed below.

2.3 Data collection for Value of Time

An extensive literature is available on VOT studies with more than 100 studies conducted in UK only. These studies have been focused on modelling and forecasting Value of Travel Time Savings (Mackie).

Value of time studies have considered all trip purpose to distinguish VOT among them. Studies which were conducted irrespective of trip purpose constitute a smaller share of around 25%. Besides, for studies investigating mode used and mode valued Car appears to be most researched before bus and rail transport mode (Pedro A.L. Abrantes, 2010).

VOT assessments on the basis of trip distance is also abundantly available in literature with 80% of the observations below 50miles. Studies also reveals walk, wait and Out of Vehicle Time (OVT) below 10miles for 85% of valuations.

Previous studies had also concluded that in case employers pay for extra travel time or late arrivals than VOT is slightly higher. Similarly, for those who are self-employed this question contains no meaning (Mackie).

Swiss studies previously followed Revealed Preference sources while some of their recent work is based on Stated Preference methods. Besides the conventional mode choice studies, Axhausen demonstrated that route choice for public transport users can also be modelled through SP surveys (Kay W Axhausen). This study also tried to project VTTS through destination choice experiment however the results were unrealistically high and thus dropped. Variables used were cost, travel time in congested and uncongested network.

For any data collection associated with VOT (or mode choice at large), either a Stated Preference (SP) or Revealed Preference (RP) approach is employed. RP studies were common during 1960 – 1970 where they constituted around 92% of all such studies. However, with the passage of time many developments were made in SP studies including SP choice, SP ranking and SP rating studies. For last half a decade (2005-2008) SP Choice studies are most common with around 93% of these studies (Pedro A.L. Abrantes, 2010). Both of these approaches are further explained in next sections.

A number of parameters are associated with VOT estimation. Amongst them, trip purpose, wage rate and travel mode are abundantly available in literature. However, all the parameters are discussed below with their reason of inclusion in classical VOT literature.

2.3.1 Trip Purpose

Travel comprises of various purpose from personal to work and other errands. They include shopping, education, hoteling, religious, or other purpose. The VTTS fluctuates drastically from one purpose to another. For instance, reaching destination at/before time is strictly implied for work trips which results in optimizing route and travel mode. Otherwise, a person may select a longer but more comfortable path.

2.3.2 Travel Mode

In this mechanized era, heterogeneous traffic is observed for passenger travel. Between modes, the travel time, comfort, safety and other parameters fluctuate and so does the value of time. It is hereby important to understand that VOT can vary intrapersonal with different travel mode for a specific trip purpose. Therefore intrapersonal attributes are further explained in detail.

2.3.3 Personal Attributes

The basic personal attributes such as gender, age, income, employment, education and other socioeconomic features play a significant part in the complex trip planning process of any individual (Belenky, The Value of Travel Time Savings: Departmental Guidance for Conducting Economic Evaluations, 2011). In addition, these characteristics also have an impact on their VTTS. In circumstances, where vehicle occupancy is greater than one, specifically in Public Transport (PT), the VOT is different for each commuter.

The Willingness to Pay (WTP) can differ from person to person, in favor of a faster or more comfortable travel depending on the capacity to spend, hourly wage rate and personal preferences. Most basic concepts of VOT allocate 'total travel resources' which are consumed for travel by individuals. This resource is a fraction of income, designated as travel expenses (resources). Total amount of travel undertaken by individual, irrespective of modes, must comply with resource constraints. FIGURE 2 below shows this concept as described in Applied Choice Analysis: A Primer by Hensher (David A Hensher, 2005).

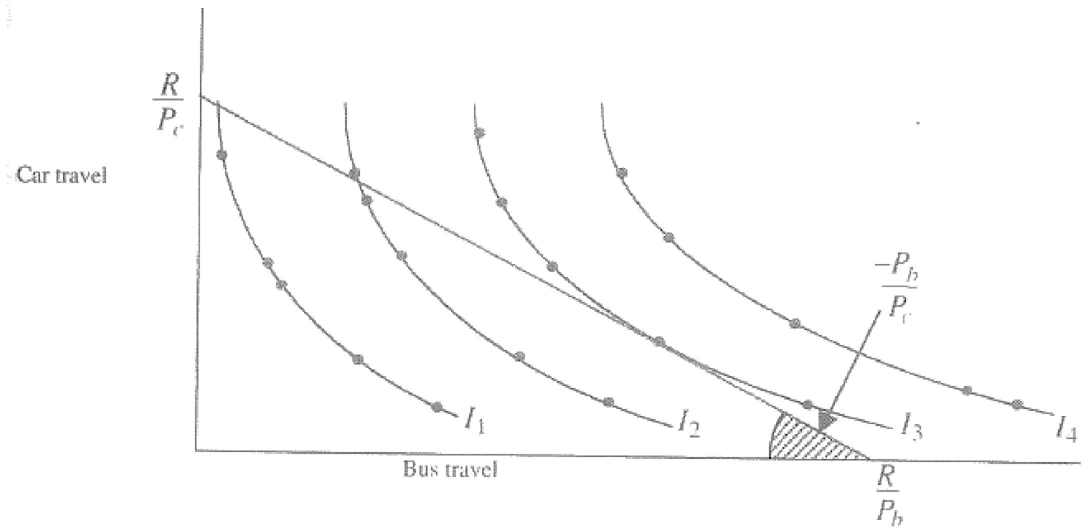

FIGURE 2 Budget or Resource Constraint.

Where
R = Total Resources (budget constraint)
P_c = Price of Unit travel of Car and
P_b = Price of Unit travel of Bus
I_{1-4}= Indifference Curves

The space in the above FIGURE 2 is called utility or satisfaction space and it defines the total travel utility of individual amongst two modes (here referred as bus and car respectively). Points having same utility (satisfaction) are joined together to form indifference curves. R/P here expresses total possible travel for any specific mode. The slope of R represents the cost ratio for both modes.

2.3.4 Comfort

Comfort differs between modes of transportation such as walking, motorbike (referred as bike later on), car, PT. Although it is difficult to examine, it has been successfully implemented through the ratings scale (Khan, 2007). However, the perception of comfort still can vary from one person to another.

These estimated values are frequently utilized in appraisal work for many transportation related projects. They remain to be the plausible in ameliorating

VOT studies to date. From English-speaking countries to Latin America, Asia, Australia, Netherlands and Scandinavian countries; these studies have been implemented everywhere.

Furthermore, VOT studies aim to reduce travel time for other benefits through infrastructure expansion. These benefits aim either to reduce the travel time between two locations or intends to improve the journey environments. The former case refers for instance to an additional lane or increased transit frequency, while the latter one aims at planning at a broader policy level. The reduction in travel time can either be replaced with a productive (revenue generating) activity by the commuter, any other activity, or even by a simple reduction in stress and fatigue due to the reduced travel.

2.4 Revealed Preference

Revealed preference (RP) deals with current choice undertaken by respondent. They only analyze the current transportation behavior observed by the individuals. Still, many studies to date, including that of Carlo Fezzi (Carlo Fezzi, 2013), have studied the RP approach for estimating VOT.

2.5 Stated Preference

SP data collection is more common for VOT estimation as it allows to analyze more insights related to new modes.

In this method, the respondents are provided with hypothetical scenarios which are close but not observed in real world. In SP surveys it is important to formulate choices which can be practically implemented keeping in view the constraints such as traffic rules, pertaining to speed limit or unrealistic travel attributes. For VOT estimation, SP are preferred over revealed preference surveys (Louviere, 2000).

SP studies gathered momentum after 90’s before which researchers were parsimonious in Stated Preference Studies. In addition to that, various new modes such as tram and rails were also introduced in UK which paved the way for SP to enter in market as an analytical tool. Feasibility studies including the frequency, waiting time and fares of a new Public Transport (PT) can also be evaluated through SP survey.

Stated Preference are kept simpler (in terms of attributes and their levels) in European studies while, the relevance of SP surveys is given more attention by others in its application (Pedro A.L. Abrantes, 2010).

There are many reasons for researchers’ inclination towards SP surveys including but not limited to:

1. They allow to analyze hypothetical choices as compared to revealed preference, which works on only current travel mode.

2. It predicts the feasibility for new transport modes.
3. It makes the respondent to think deeper in selecting/ ranking choice from large options.
4. Data collection for SP surveys is cheaper as compared to RP surveys.
5. SP can introduce self-variation in parameter values in case it is not present.

Similarly there are also some disadvantages of SP surveys.

1. SP survey needs to be small to persuade respondents to answer.
2. It has low response rate as major information is to be provided by respondents.
3. For a large questionnaire, the response rate may be as low as (50%).

Mathematically, different approaches have previously been adopted by researchers for VOT estimation. All these approaches are discuss below independently.

2.6 Prospect Theory

The prospect theory was developed to investigate the descriptive-behavior (Kahneman, 1979). He expressed the concern that only a marginal rate of respondents followed Utility Theory (UT) whereas the mainstream followed the prospect theory. The prospect theory was further modified by same researchers and called as Extended Prospect Theory (EPT).

While answering to a Stated Preference (SP) questionnaire, EPT assumes that each individual has a specific approach. This specific approach is termed as 'choice sequence' by Van de Kaa. Within the context of this choice sequence, a specific parameter is considered as most significant, such that the effect of other attributes holds negligible in the final decision. While this behavior is valid for an individual, that specific parameter may vary within a group of respondents. To elaborate: consider the two important parameters cost and travel time. While outcomes of an individual implies the option with minimum travel time as the choice in all choice sets, it may be vice versa that the option with minimized cost, irrespective of travel time, is the selection criteria for other candidates. This results either in a very low VOT or very high VOT when the controlling parameter is cost or travel time respectively.

The above insight, for selecting alternative, makes Utility Theory weak if such observations are not omitted during analysis. These postulates have been investigated by many researchers including Ortuzar (Rizzi, 2003), (Iragüen, 2004) and (Saelensminde, 2001). It is therefore recommended that the answers that comply with lexographic reaction (strong hold of a specific parameter) should be eliminated from analysis, unless that lexographic response follows some other function and complies to the principle of UT also.

Although this relates to a large extent for hypothetical choice set, it cannot be fit for a trip which has been regularly conducted previously, such as work trip. As attributes of these trips are well-known for respondents.

Additionally, there are other rules that may be followed in survey responses such as random choice selection, or "stick to the left-hand side" (Van de Kaa). As these methods do not correspond to any particular choice behavior, they should be neglected from the dataset before analysis.

2.7 Utility Theory

In research, after Binary Logit Model, Multinomial Logit Regression Model (MNL) are the most common choice models where there are more alternatives available to an individual. In Disaggregated Transport Modelling i.e. at individual level, MNL models are most commonly utilized (Juan de Dios Ortuzar, 2011). These models utilize the 'utility' maximizing function to choose amongst the alternatives. This utility can be defined through numerous parameters such as travel time, cost, comfort, safety, availability, frequency (for public transport) etc. A weight is associated with all these parameters, which identifies the impact of each parameter on the estimated utility. A general utility equation is shown below.

$$U_{i1} = \alpha + \beta_1 TT_{i1} + \beta_2 TC_{i1} + \beta_3 C_{i1} + \beta_4 S_{i1} + \beta_5 A_{i1} \dots \dots .. \beta_k K_{i1} \quad (1)$$

Where,
ɑ = Constant (Alternate Specific Constant (ASC) if it is distinguished for each mode as ASC)
U_i = Utility of individual i for mode 1.
B_1 = coefficient of Travel Time for individual 1.

The alternative having the highest utility is selected through a maximum likelihood function. It is hereby necessary to understand that maximizing utility is not only minimizing Travel Time and (or) minimizing Travel Cost but as a function of all attributes while adhering to available constraints such as income (Kaa, Answering, Assessment Of The Value Of Travel Time From Stated Choice Surveys: The Impact Of Lexicographic Answering). Previous studies have utilized mode choice models in value of time estimates by dividing coefficient of Travel Time with coefficient of Cost. This leads to the estimation of Value of time/ unit time.

2.8 Logit models

Logit models are the most common models used in Value of Time Estimation. Logit models are discrete choice models and have the capability to model more than one outcome and their associated probabilities. For mode choice models, the outcome or dependent variable is mode choice whereas predictor variables are associated parameters. The equation below shows the linear predictor function:

$$t = \beta_0 + \beta_1 x \ldots. \quad (2)$$

Where,
t = outcome
B_0 = Constant
B_1 = Coefficient of x variable

In order to convert this linear function to probabilities logistic function uses the concept of 'odds' as shown below. Odds explains the probability that a certain outcome will be achieved over another outcome. This restricts the probability values between 0 and 1. The logit function of these odds converts the outcome into continuous form. This continuous form allows the forecast at any given value. The equation 3 below shows the form of Binary Logistic function whereas equation 4 shows its inverse or log odds

$$F(x) = \frac{1}{1+ e^{-(\beta_0+\beta_1 x)}} \quad (3)$$

$$G(x) = ln\frac{F(x)}{1-F(x)} = \beta_0 + \beta_1 x \quad (4)$$

F(x) is probability and

G(x) is logit (log odds) function and corresponds to linear regression

2.9 Odds

Logit function associates the linear regression function and their probabilities. Similarly, the odds are the exponential form of the regression function based on a number of predictor variables. To be clearer, equation 5 below shows the odds.

$$Odds = e^{\beta_0+\beta_1 x} \quad (5)$$

Once the odds are defined the odds ratio are calculated against any base category.

$$OR = \frac{Odds\ (F(x))}{Odds\ (F(x+1))} = \frac{\frac{F(x)}{1-F(x)}}{\frac{F(x+1)}{1-F(x+1)}} \quad (6)$$

Through these odds ration the significance of any attribute for each outcome can be predicted i.e. how much a unit change in attribute will affect the odds ratio of a certain outcome. The application of this method is well explained in literature at various places (Regression Using Excel's Solver, n.d.), (Zaiontz, n.d.).

2.10 VOT Estimation through Logit Model

Logit models, as explained above, are applied in this research. Travel Time (TT) and Travel Cost (TC) were used in the analysis. The coefficient of these parameters in a logit model ascertain the significance of TT and TC in a choice outcome. Likewise, the ratio of their coefficient determines the value of unit (time) gain or loss. To explain it mathematically, equation 6 below shows the VOT formulae.

$$VOT = \frac{\beta_{TT}}{\beta_{TC}} \qquad (7)$$

Where,

B_{TT}= Coefficient of Travel time (1/min) and
B_{TC}= Coefficient of Travel Cost (1/$)

Hence, Value of Time is represented as (Cost/h). This is a generalized expression and can be used for as many available choice (modes).

2.11 Positive Travel Utility

According to basic transport phenomenon, as previously discussed, travel is heavily considered as ‘means’ to reach a desired end which are activities themselves. Majority of transport policies reflect this concept and are therefore focused on minimizing travel.

Contradictory to above mentioned postulate, many researchers including Salomon in the field of economics and urban planning have explored the positive aspects (utility) of travel time. Further ahead, they commented on the offstage motives which make travel as a desired activity such as adventure, environment exposure, independence, scenery and even physical exercise (Mokhtarian P.L., 2001). They modelled various combinations of mode and trip purpose using socioeconomic, personal lifestyle and attitudinal indicators. They concluded a direct relations of all these variables on daily travel patterns.

Arentze and Timmermans reported the availability of expected information can motivate travelers to opt for distant activity locations and even longer routes Arentze and Timmermans (n.d., cited in Mokhtarian (2015)). Therefore, based upon exploration and variety seeking, travelers can overlook the shortest path. Similarly, Steg studied the motives of people travelling in car by categorizing factors as vehicular (safety, comfort), emotional (enjoyment, pleasure) and symbolic (prestigious, icon of respect) and she concluded the former as the least influencing parameter (Steg, 2005). Hence, the conventional approach of calculating utility can be questioned as most of the utility value still remains to be observed or is a part of error id. Further down the line it also explains the resistance to use Public Transport for Car despite a number of policies introduced in various regions.

Mokhtarian also commented on the study conducted by Anable and Gatersleben for mode choice in UK in their separate studies and reported same behavior as of Steg in Netherlands (Anable, 2005) (Mokhtarian, 2005). However, more interestingly their research also concluded the car choice as a result of strong response (highest weight of any parameter) due to its “convenience”; as reported by Kaa (Kaa, Answering, Assessment Of The Value Of Travel Time From Stated

Choice Surveys: The Impact Of Lexicographic Answering). To add to the list, Handy reported "people drive not only because they have to but also because they want to" (Susan Handy, August 2003). Mokhtarian compared traveling, irrespective of mode, as a healthy physical activity compared to just sitting at home.

A study conducted by Centre of transportation research also reported positive utilization of travel time by rail passengers with a huge percentage disagreeing to ruminate travel time as a waste (Research, Accessed November 2010).

Ettema analyzed the VOT on the basis of personal attributes by dividing travelers into 'monochromic' (those who do not prefer to do any other task during travel) and 'polychromic' (those who prefer to do multitasking). As per intuition, VOT was high for passengers who do not perform any other task during travel and vice versa (Ettema, 2010).

Richardson investigated if each traveler has some VOT or some travelers have no VOT, which he termed as 'zero value of time' (Richardson, 2003). Through a survey conducted in Singapore he concluded VOT to be dependent on mode and that a small percentage of public transport users had zero value of time. Similarly, Cirillo reported the variation in VTTS not only depends on mode, purpose, tour type and departure time but a small percentage of respondents wish their travel time could be extended (Cirillo, 2004).

2.12 Scheming Travel time as a habit

The current travel mode is more an outcome of personal habits and practices than any other constraints. This fact was elucidated by Waldo through in-depth surveys (Waldo, 1999). De Borger and Fosgerau, in their study (de Borger, 2006), provided respondents with alternative choice based on their current trip. They concluded three major advances in mode choice modelling:

1. Reference point theory explained the choice undertaken very well.
2. The fluctuation in VOT with level of time difference between different choice set.
3. Respondents 'carry' their VOT (unobserved) to other transport mode. For instance, car drivers have higher VOT for bus as compared to bus users and bus users have low VOT for car as compared to conventional car users.

2.13 Travel Time Budget and Travel Time Ratio

In relation to above concept, is the existence of a Travel Time Budget (TTB). TTB explains the maximum time that an individual can spent on his travelling. TTB can vary among individuals and with activity type. The estimation of TTB can play vital role in VTTS by indicating that any travel time saved (i.e. TTS) was used for travel itself rather than any other activity. On this notion, Metz hypothesized that average travel time remains relatively constant. Later, as evidence he performed meta-analysis aggregate household data (Metz, 2003).

Dijst explored the Travel Time Ratio (TTR) (ratio of time spend to reach a particular destination and total time spend at that location) for various trip purposes (Dijst, 2000). Each activity has a maximum preferred travel time which he stated as 'turn-over point'. Above this point TT was a disutility and affected the time that needs to be spend on other activities. Dijst however ignored the possible third dimension of mode in estimating TTR.

In line with this Turcotte asked the respondents if they actually like the time they spent on travel. About 20% of respondents who enjoyed their commute used to travel on bike. Therefore, mode choice does possibly have an impact on travel time and TTS at large (Turcotte, 2006).

A thorough study of literature review provided empirical evidence of numerous sections in Value of Time estimation. The concept of fixed travel time for each activity across individuals and consistency in marginal utility of time (without any effect of marginal utility of cost) has been the basis of further research.

2.14 Summary

The questions now arises: if people really like to travel then why does travel time has a negative coefficient in utility function? There are possible various reasons of a negative utility of travel time in all conventional models.

1. Researchers discard the models which are not conferring to their expectations
2. Travel time may be positively viewed by a small portion of population
3. Travel time itself may not have a positive effect but only a portion of it which is not modelled.
4. Positive coefficients of travel time does not confer to microeconomic theory (time is a limited resource and people tends to save it).
5. Positive associations of travel time may refer to some sort of data limitations.
6. Productivity during travelling was around 98% to that of office environment (Fickling, 2008).

A new dimension to this subject has been provided by increasingly use of the Information and Communication Technologies (ICT). There are number of ways in which the use of ICT directly relates to travel time.

1. ICTs are blurring the boundary between travel and activity as previously used in activity based models. For instance working through laptop during a train journey.
2. ICTs diminishes the concept of travel as a burden and the motivation to reduce travel time.

Lyons and Urry distinguished the efficiency of travel time from person to person as either less, equal and ultra-productive hence opening a new chapter in valuing travel time savings (Lyons, 2005).

The above mentioned contributions feeds to a series of questions that needs to be answered on quantifying the value of travel time. How to monetize travel time based on transport alternatives? How to quantify personal attributes into demand forecasting models? How to measure positive utility of travel as it vary person to person?

2.15 Way forward

This section elucidated the general concept of VOT and its importance in transport planning. It also highlighted some VOT studies conducted previously, their research setup, data collection schemes and their advantages. It also explained the most often used models used and their implementation methods. The above explained method of VOT estimation through Multinomial Logit Models is applied in this research. The next chapter of this report explains the study area, data collection and research setup and also results achieved.

Chapter 3: Value of time in case of Traffic Congestion

3.1 Introduction

This chapter explains the value of time according to mode choice. The focus of this research, is to conduct Value of Time Estimation for National Highway, which connects Karachi city with Port Qasim Industrial area. Karachi is a mega city in Asian subcontinent and the biggest city of Pakistan with a population of around 23 million (Amer, 2013).

This research aims to focus on the work trips, as these trips have largest share of travelers through this highway to reach their work place. Traffic congestion and delay losses were quantified on this stretch to be around 30,000US$ per day (Mir Shabbar Ali M. A., 2014). These extreme figure demands analysis of commuter's loss by quantifying Value of Time.

For this research, VOT estimations are estimated for 'passenger transport'. Freight transport also passes through the stretch but their VOT assessment is not part of this paper. VOT is assessed for Private Car users and other transport users separately. Although it has been previously emphasized by many researchers, including (William F. Mcfarland, 1985), to analyze VOT against mode. There are various reasons for this stand-out approach. Primarily, this VOT is calculated for commuters through this stretch which serves as an 'industrial area'.

The absence of any 'alternative route' prevents the commuters to avoid this highway. Under such circumstances differences within-mode, such as the comfort level, are diminished. Further ahead, the free flow speed or design speed is unattainable and hence a reason of increased travel time. Moreover, lower average speed, upsurges security concerns and stress for commuters besides dropping comfort level. Therefore, parameters used to assess VOT were only travel time and cost.

The next section of this chapter describes the study area of the analysis, followed by the methodology and data analysis. Last section of this chapter expounds the results obtained followed by future work.

3.2 Study Area

National Highway is a 20km stretch which links Karachi to main arterial 'Shahrah e Faisal' at one end and connects Port Qasim Industrial Area at other end. It comprises of nine intersections from 'Start Gate' intersection to 'Pakistan Steel' intersection. Each section is a two-way two-lane median separated. In contrast, average volume per hour is (around 4500 vehicle/h) above road capacity (Mir Shabbar Ali M. A., 2014). This network is available for passenger and cargo transport and therefore is under excessive load. Approximately above 100 medium and high scale industries are located in Port Qasim area. A highly heterogeneous vehicular mix uses this stretch which includes various passenger transport, para-transit and public transport whereas for freight transport heavy trailers traverse all-day. There is also an oil depot situated in this area which sets movement of oil tankers in the same stream. FIGURE 3 below shows the Google imagery of the study area.

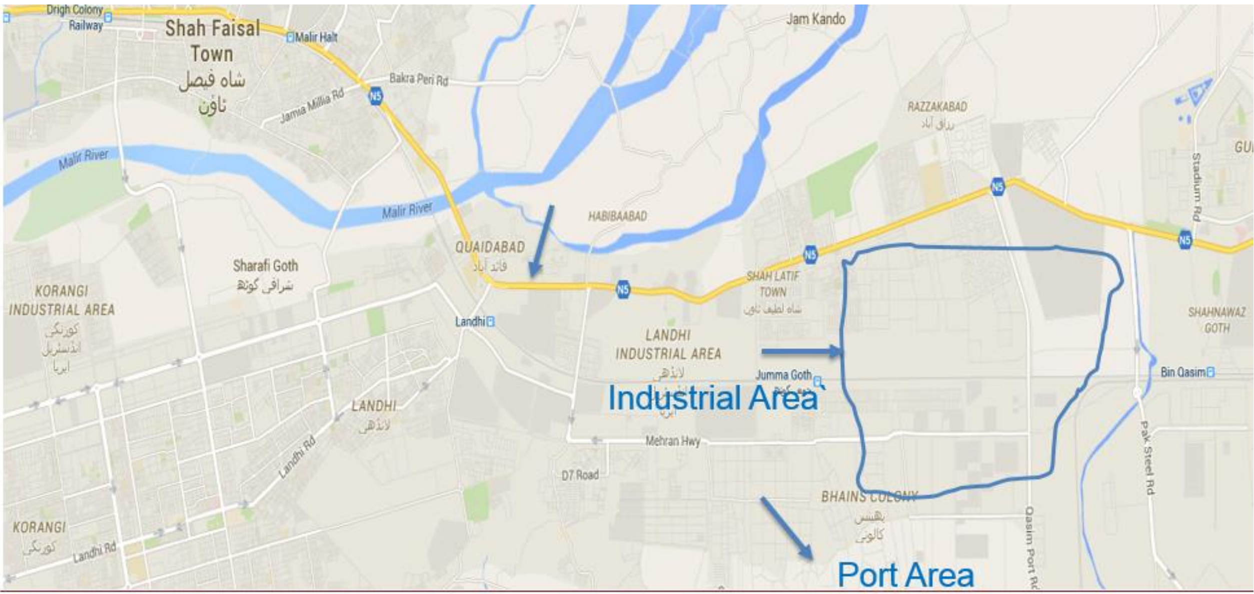

FIGURE 3 National Highway Stretch.

There are several transport related issues which sum up to make this essential highway as one of the busiest, choked and packed stretch in the city. These problems include irregular parking, which converts the 3 lane stretch into a 2 lane. FIGURE 4 below highlights the stated issue. In addition, a number of access/egress points are used by heavy vehicles for turning movement and thus reduces the speed of trailing vehicles drastically and, most importantly, the degrading pavement adds to traffic congestion. FIGURE 5 illustrates this problem along with degrading condition of pavement.

FIGURE 4 Irregular Parking at National Highway.

FIGURE 5 Turning Movements by Oil Tanker.

Based on the above mentioned facts, this site was chosen for VOT estimation. Data collection and research methodology are explained in next section of this chapter.

3.3 Data Collection and Methodology

Data for VOT was collected through Stated Preference (SP) survey. This survey was conducted at various industries located in Port Qasim Industrial Area where employees commute daily through this stretch. A paper based questionnaire was developed where interviewees were given hypothetical mode to choose from. FIGURE 6 below illustrates the step-by-step procedure of analysis.

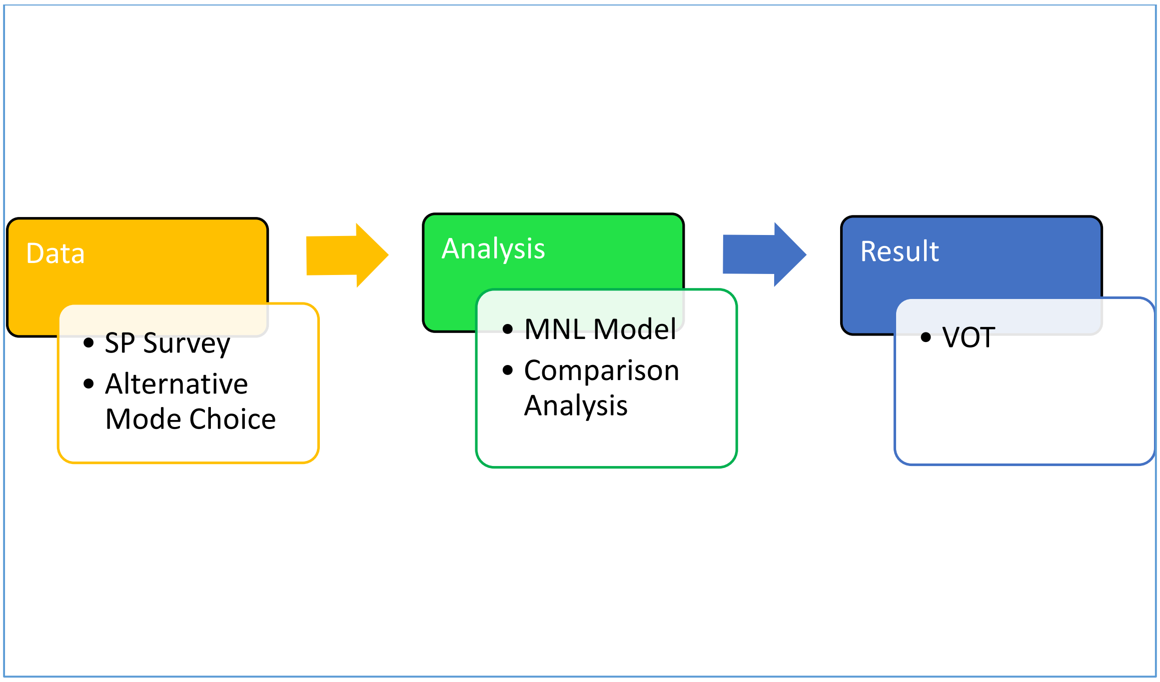

FIGURE 6 Research Procedure.

The survey form (shown in appendix A) comprised of two sections. The first section gathered socioeconomic data such as age, gender and income status. Also, travel attributes such as origin, destination, mode, travel expenses and journey time were collected. Journey time was further divided into average, smallest and highest time. Some descriptive questions, such as, most common reason for delay and its solutions were asked. There were some secondary questions such as fuel type, number of daily trips, KM travelled and monthly travel expenses.

The second part of this survey was related to SP data. The options from which the respondent could choose from were provided based on 'current mode'. For private-car users other modes were bike (in case of ownership), auto (3-wheeler), van and public transport. The travel time and cost parameters in proposed choices were formulated to be realistic by satisfying constraints such that maximum achievable speed by vehicle under circumstances.

These parameters for alternative modes were defined as a function of current time and cost so they remain stochastic. All the respondents, irrespective of their current mode, were given the same hypothetical mode choices to choose form except their current mode, which was eliminated from alternative choice. There were total 5 modes (car, public transport, bike, three-wheeler and van) of travel. This resulted in 4 hypothetical choices to each respondent with 5^{th} being their current mode.

Other common parameters such as comfort and safety were not included in the data. As the average speed remains same, it is hard to discriminate comfort level in-between different modes. Therefore, attributes for hypothetical choices were only travel time and travel cost. These were a function of 'current travel time and travel cost'. FIGURE 7 below highlight the information collected in survey.

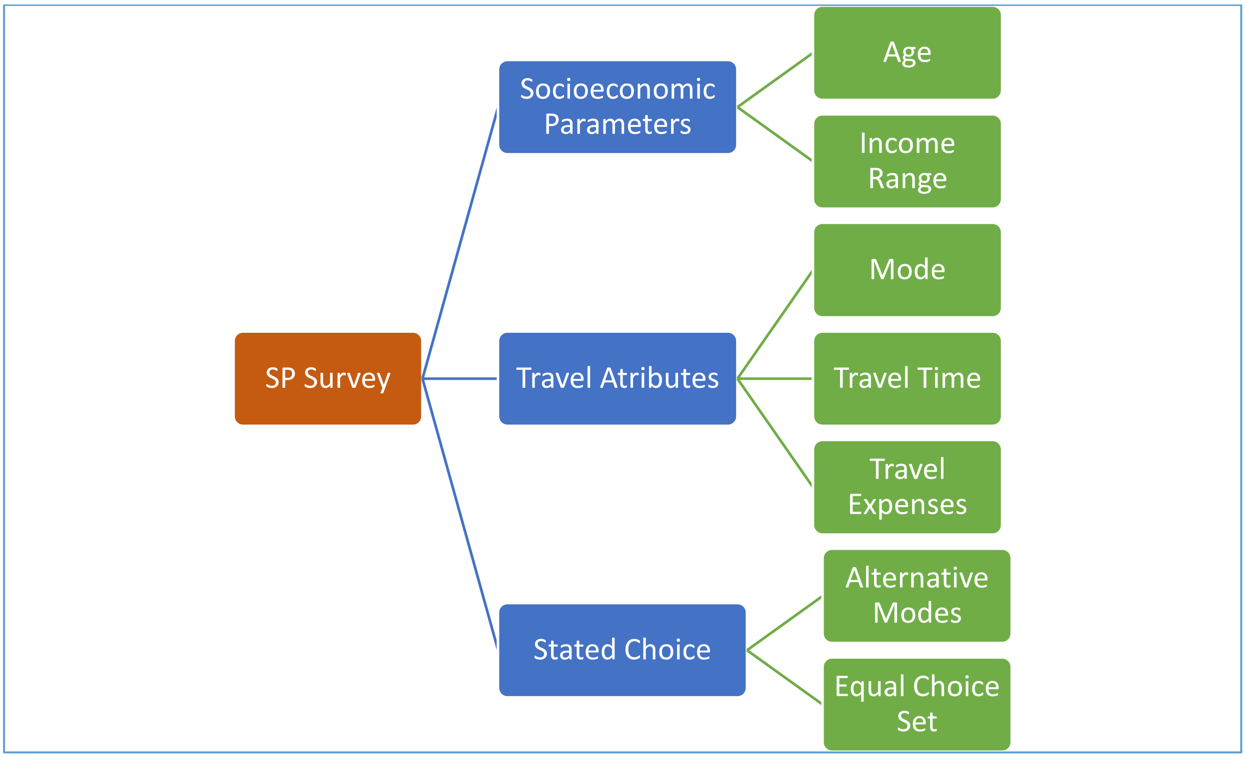

FIGURE 7 SP Survey Data.

It is important to comprehend the procedure through which levels (values) of alternative attributes were formulated. Travel time and cost for each alternative attribute were articulated as a function against base mode. For instance, if current mode is private car and the alternative mode chosen is bike, then travel time and cost for alternative mode will be lower and higher respectively. Each respondent was provided with an equal choice set of four alternatives. TABLE 1 shows the time and cost values for every alternative mode against current mode. It can been from the table below that travel time for private car and three wheeler were the same, however their cost vary. The travel time for bus and van were similar, but travel cost for a bus was lower than that of a van. For cost, the indifference was only between can and three-wheeler.

TABLE 1 Attributes Values against Base Transport Mode.

Current Mode	Alternative Choice	Travel time (minutes)	Travel cost (PKR) 100PKR = 1US$
Car	Public Transport	20	-50
	Three-Wheeler	Same	30
	Van	20	-30
	Bike	-10	-30
Public Transport	Car	-20	50
	Three-Wheeler	-20	70
	Van	-10	50
	Bike	-20	30
Van	Car	-20	-30
	Public Transport	Same	-80
	Three-Wheeler	-20	Same
	Bike	-30	-60
Bike	Car	10	30
	Public Transport	25	-20
	Three-Wheeler	10	60
	Van	30	60

This data was acquired from NED University of Engineering and Technology collected for Toyota Research on Traffic Congestion (T-RTC) project funded by Indus Motor Company in 2012.

Interviewers were selected through clustered sampling based on the income group. Employees having lower income were more sampled whereas employees having higher income were less interviewed. Individuals with higher income were less signified as their impact on Value of Time is very momentous. Additionally, the same distribution is observed among employees of a firm. FIGURE 8 shows the number of applicants with respect to their income group. A total of approximately 700 samples were collected however, only respondents who provided complete data were used for analysis. This reduced the sample size to 554 respondents.

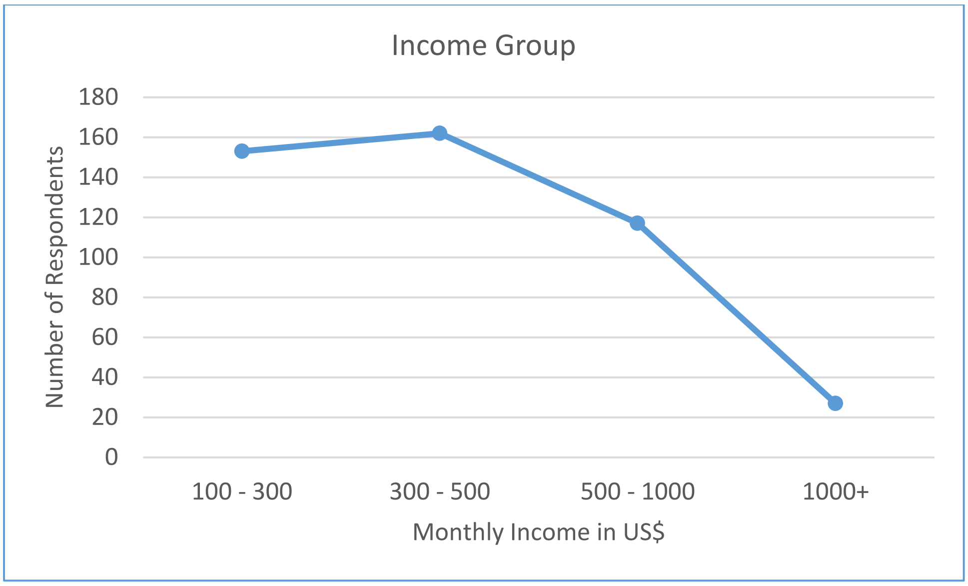

FIGURE 8 Sample size of Interviewees.

3.4 Result and Discussion

This section explains the results obtained and their logical reasoning. FIGURE 9 shows current mode of the respondents. It is evident that car is currently most common mode of transportation. Similarly, bus was least preferred mode of transport. It is currently due to the fact that industries are located at a distance from main highway therefore average walking time is around 20 to 25 minutes (except in case of lift from other car users). Van, unlike public bus, has less walking distance as it picks employees from nearest possible stop and drops at work place. Further ahead, in case of any emergency or bad weather they are readily available which is opposite in case of public transport.

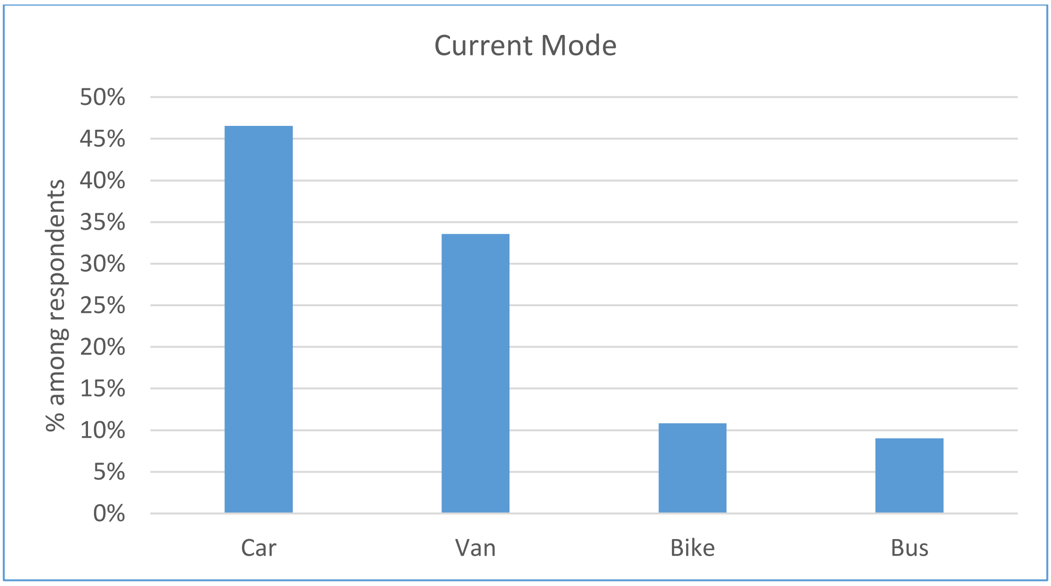

FIGURE 9 Current Mode.

FIGURE 10 shows the alternative (stated) mode selection based on their current travel mode. Currently, three wheeler is not used at all as travel mode. However it was chosen as alternative by many respondents, especially those travelling by public transport. As seen in the figure below, a complex pattern is observed from all passengers. For instance, majority of those travelling on private car chose company van as their alternative. Secondly, van passengers opted for car, however a small percentage also preferred to use bike. Those travelling on public transport only opted for three- wheeler or van as these commuters do not typically own a vehicle. Generally public transport was least preferred by transport mode users.

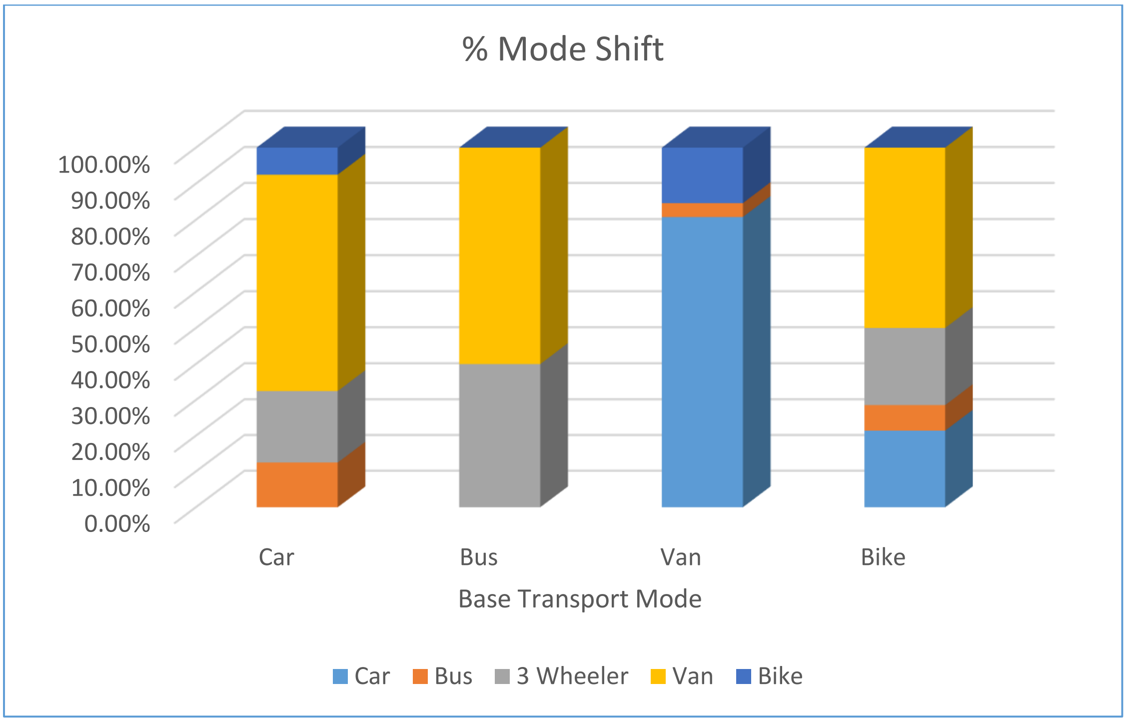

FIGURE 10 Stated Mode against Current Mode.

A Multinomial Logit Regression Model (MNL) was implemented through utility theory by maximizing Log Likelihood. There were two utilities for current and alternative modes for each individual separately. The equation below was used for estimating utility.

$$U_i = \beta_0 + \beta_1.TT_i + \beta_2.TC_i \quad (8)$$

Where,

U_i = Utility of Mode i (i= Car, Bus, Bike, Van, Public Transport, Three-Wheeler),
TT_i= Travel Time for Mode i,
TC_i= Travel Cost for Mode i,
B_0= Intercept,
β_1= Coefficient of Travel time (1/min) and
β_2= Coefficient of Travel Cost (1/Rs).

Travel cost and time for alternative mode were predicted through current mode's attributes. Utility was calculated for individual for each alternative through Solver extension in MS Excel. From the utility, probabilities were derived with current mode as base case for each individual. Lastly, the aggregate log-likelihood (In) was maximized based on the values of the coefficients. The coefficients were the constant, cost and time coefficient. The sum of Log-likelihood values was maximized through this function while optimizing constant, cost and time coefficients. FIGURE 11 demonstrates development of MNL model in Excel.

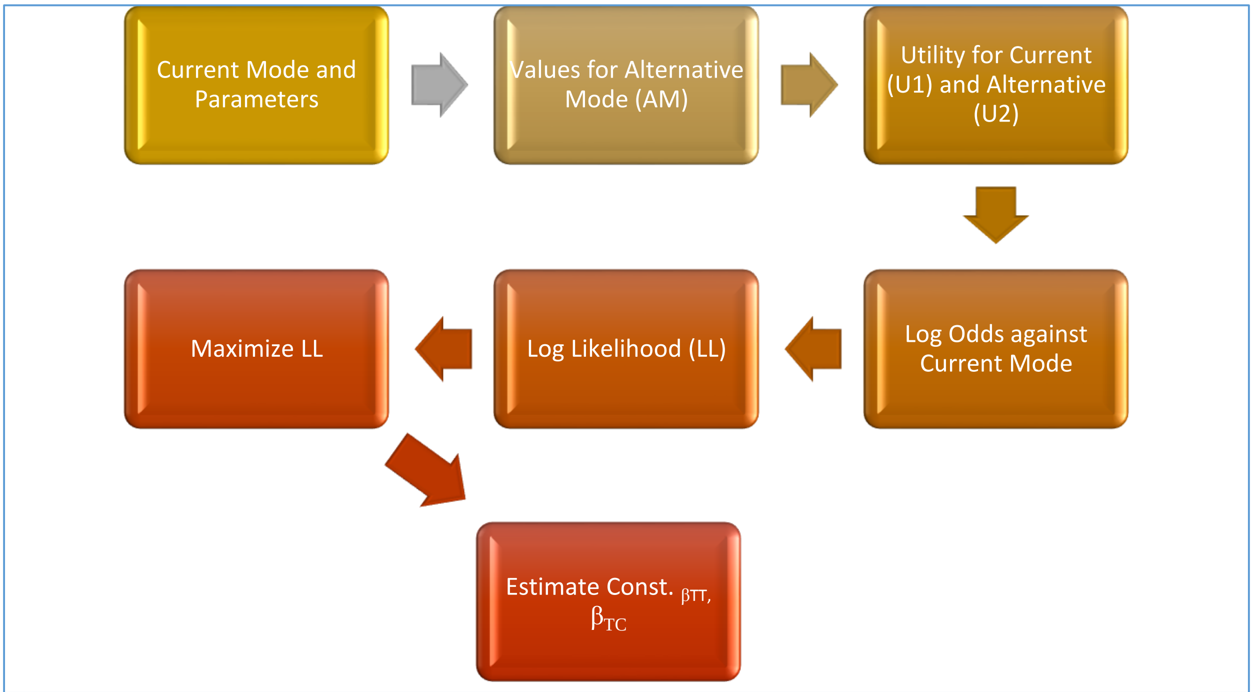

FIGURE 11 MNL Model.

Travel time increase during congestion and peak hours which reduces its reliability (Carlos Carrion, 2012). Therefore, to introduce variation, travel time and cost for alternative modes were provided stochastic nature (variation) through multiplication with a random variable. This variation was kept under observed limits of travel time obtained from (Shabbar et al). MNL regression was applied for car users and other mode users separately.

From the equation below, the obtained coefficients of Travel Cost and Travel Time were divided to estimate the Value of Time.

$$VOT = \frac{\beta_1}{\beta_2} \quad (9)$$

Through the solver function in MS Excel, following values were deduced. TABLE 2 shows the average estimated coefficient for travel time and cost after various simulations. The result is different for each simulation due to random variables, which were different each time. A negative sign denotes a disutility with an increase in both cost and travel time. However, it is primarily dependent on cost. The constant or intercept is very small and can be considered as insignificant.

3.4.1 For car users

TABLE 2 Coefficient for MNL Model of Private Car Users.

Coefficient	Value
Constant	-1.678 x E-07
Time Coefficient	-0.13156
Cost Coefficient	-0.02039

Based on these coefficients the estimated value of time is calculated to be **Rs 387/h or 3.68US$/h**. Although it is intended for only work trips in a private car, this amount is comparatively higher than in previous studies conducted in similar locations in recent years. In this case, VOT is primarily dependent on cost. The constant or intercept is very small and can be considered as less important when compared to cost.

3.4.2 For other users

TABLE 3 Coefficient for MNL Model of all other users.

Coefficient	Value
Constant	-4.026 x E-08
Time Coefficient	-0.111298
Cost Coefficient	-0.0474533

The TABLE 3 above shows the coefficients for commuters other than travelers using car. Based on these coefficients, the estimated value of time is calculated to be **Rs 134/h or 1.29US$/h**. This value, when compared to car users, is quite low. However, it is still above the average VOT for similar regions. The values obtained are not very sensitive as VOT remains same up to first decimal place. This is explained in detail in sensitivity analysis below.

To add, the fuel price for one liter petrol is approximately Rs. 100 or 0.99$.

3.5 Sensitivity analysis

In order to check the sensitivity of these figures, a sensitivity analysis was performed. It intended to introduce variation in travel time and cost for alternative modes. This intended variation represented unreliability in actual travel time and cost due to congestion. The said randomness was specified through by a "random variable" function and was around 10 to 25% of the mean values. This corresponds to 5 to 10 minutes of variation depending on original travel time. Although high, this reflects to actual deviance in travel time due to congestion.

TABLE 4 below shows VOT for 10 iterations. It becomes evident that the VOT remains the same for all iterations, rounded to one decimal.

Sensitivity analysis was repeated for higher randomness and the VOT results then obtained were nearly the same. Therefore, it can be concluded that the VOT obtained with this method is highly plausible.

TABLE 4 Sensitivity Analysis for VOT with low variation.

S.No	bTT	BCC	VOT $
1	-0.10584	-0.04737	1.276755
2	-0.10789	-0.04756	1.296199
3	-0.10839	-0.04709	1.31519
4	-0.10523	-0.0472	1.273935
5	-0.10844	-0.04742	1.306825
6	-0.11047	-0.04791	1.317691
7	-0.10724	-0.04713	1.300243
8	-0.10981	-0.04804	1.306295
9	-0.10748	-0.04664	1.316811
10	-0.10572	-0.04687	1.289045
		Average =	**1.299899**

As stated above, the variation in VOT is less than 5%. Further ahead, the randomness of Travel Time was further enhanced to twice of current randomness i.e. around 15 – 20 minutes of uncertainty. The TABLE 5 shows VOT for 10 iterations with high uncertainty in travel time and cost.

TABLE 5 Sensitivity Analysis for VOT with high variation.

S.No	bTT	BCC	VOT $
1	-0.10691	-0.04797	1.273402
2	-0.1003	-0.04821	1.188962
3	-0.10393	-0.04811	1.234441
4	-0.11035	-0.0486	1.297616
5	-0.10385	-0.0466	1.273425
6	-0.10846	-0.04723	1.312295
7	-0.10005	-0.04749	1.203818
8	-0.09771	-0.04616	1.209508
9	-0.09897	-0.04692	1.205361
10	-0.09662	-0.04697	1.1755
		Average =	**1.237433**

This time, variation in VOT is also increased with deviation in travel time however, upper limit remains same whereas average VOT is slightly lowered. This trend is also shown in FIGURE 12 below.

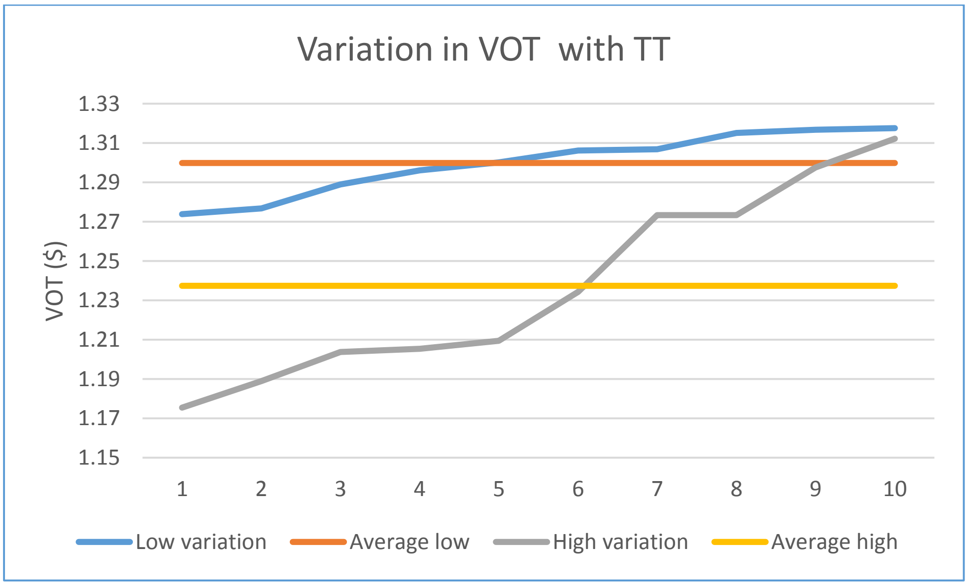

FIGURE 12 Variation in VOT with TT.

The above analysis thus sets the VOT calculated to be precise. Moreover, it also figures out high difference in car and other vehicles VOT. Further ahead this VOT is compared with other regions.

3.6 Comparison Analysis

TABLE 6 below shows the estimated Value of Time as a comparison. The VOT varies from region to region however remains below the 1$ mark for all. Amongst them, the lowest Value of time is of Pakistan. This study was conducted in Karachi in which our study area also lies. Further ahead, that study area was the complete Karachi city. Karachi city shows huge diverse demographic variation, from some posh areas to many slum localities. The people of the localities usually prefer-to-travel by foot to earn their living. Therefore, as an overall estimation, a VOT of 0.32 €/h is quite reasonable. Similarly, Farhad revealed diverse VOT values for Bangladesh (Farhad Ahmed K. G., 2004).

TABLE 6 VOT for similar regions.

Country	VOT (US$/h)	VOT (€/h)
India	0.75	0.60
Srilanka	0.56	0.45
Bangladesh	0.72	0.58
Pakistan	0.4 (JICA)	0.32

The calculated, higher value of time can be justified considering the facts mentioned earlier. First, this VOT is solely estimated for work commutes through a saturated and highly congested stretch. Secondly, only motorized transport can be used to reach the work area as it is separated from the residential areas. Thirdly, a huge amount of congestion increased the value of unit time saved. Most importantly, it also provides an important planning insight where project cost and benefits are imperative criteria in determining its feasibility.

Interestingly, previous researchers including Kenneth M. Gwilliam have revealed huge intermodal differences in VOT. He also stated that Value of Travel time Savings (VTTS) in congested conditions and unpleasant situations is higher in UK and Netherlands (Gwilliam, 1997). He compared the VOT for different countries which are shown in the table below. Most countries in this list have socioeconomic features similar to Pakistan. The percentage difference between highest and lowest VOT for each country has been calculated, and as a result enormous differences can be observed in VOT between modes. TABLE 7 is arranged in descending order according to percentage difference in VOT. Percentage difference of VOT for current study can be labelled as average.

This table also shows VOT which are higher than the currently calculated VOT but their detailed context is not available in research.

TABLE 7 VOT (US$) comparison between Modes.

S. No.	Country	Car	Pickup	Bus	Truck	Maximum	Minimum	% Diff in Highest And Lowest VOT
1	Honduras	0.8	1	0.14		1	0.14	614%
2	Chile	5.97	8.31	30.89	4.48	30.89	4.48	590%
3	Srilanka	0.82		0.16	0.16	0.82	0.16	413%
4	Indonesia	2.06	2.06	0.42		2.06	0.42	390%
5	India	1	0.44	1.8	1.04	1.8	0.44	309%
6	Uruguay	1.1	1.1	0.29		1.1	0.29	279%
7	Kenya	0.51	0.65	0.98	1.93	1.93	0.51	278%
8	Brazil	4.46		1.28		4.46	1.28	248%
9	Thailand	1.5		0.5		1.5	0.5	200%
10	Pakistan (Current Study	3.69	1.29	1.29	1.29	3.69	1.29	189%
11	China	0.33	0.12	0.33	0.33	0.33	0.12	175%
12	Bangladesh	0.91	0.91	0.35		0.91	0.35	160%
13	Hungary	2.8			6.63	6.63	2.8	137%
14	Tunisia	1.07		0.48		1.07	0.48	123%
15	Lebanon	1.72	2.59	1.24		2.59	1.24	109%
16	Spain		42.29	21.14		42.29	21.14	100%
17	Venezuela	2.72	2.14	1.66		2.72	1.66	64%
18	St. Lucia	1.14	1.49	0.91	1.1	1.49	0.91	64%
19	Korea	2.57		1.7		2.57	1.7	51%
20	Algeria			2.96	3.37	3.37	2.96	14%

The results, on secondary basis, also reveal an urgent implementation of counter measures to reduce traffic congestion. In this regard several 'low cost' techniques can be applied to reduce the travel time such as scheduling freight transport in non-business hours. A toll implementation with low occupancy vehicles in favor of carpooling can also assist in reducing congestion.

3.7 Conclusion

The VOT analysis revealed a higher value than expected. It explains that VOT can fluctuate within a certain region based on trip characteristics. Trip purpose, travel conditions and socioeconomic status; all affect a trip radically. Value of Travel Time Savings is a worthy measure for transport project appraisals. Sensitivity of VOT should be taken into consideration as it varies with choice scenarios, socioeconomic attributes and trip characteristics (purpose, congestion, available trade-off in parameters etc.)

It also calls for reasonable selection of parameters for VOT as they are different based on the purpose of the study.

Additionally, this report identified certain lacuna which are still not available in literature such as Value of time estimation for congested routes.

Ultimately, this research reveals that VOT can be much higher for work trips in case of traffic congestion and limited availability of alternatives. Transport policies should take into account this high VOT.

These results also calls for advance study which will be covered in next chapters of this report. They are as follows:

1. To compare VOT based on other data and other areas for Karachi.
2. To investigate areas having similar VOT and their attributes.
3. To determine and compare ratio for (uncongested/ congested) VOT.
4. To determine shift in Value of Time and its reasons with alteration in travel mode.
5. Design a questionnaire survey to obtain VOT.

The next chapter of this report will also focus on the VOT for Karachi city based on previously available data. The data used will be Time Use Data which is based on daily activity schedule of individuals. Most importantly, the results will be compared to predict resemblances present if any. FIGURE 13 below explains the future work step by step.

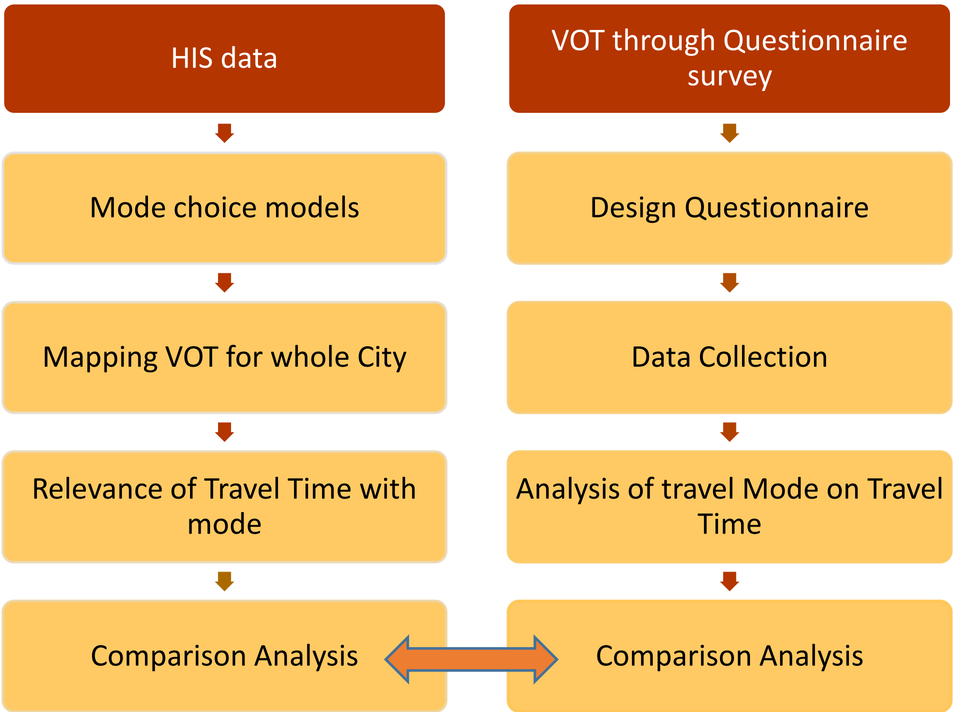

FIGURE 13 Future Work.

Chapter 4: Value of time for Karachi City

4.1 Introduction

In the previous chapter VOT for congested region was estimated. The next step is to compare the estimated VOT for Karachi city. Therefore, mode choice models were developed. These models were developed from HIS data at Town level and as a function of travel time. This chapter first describes these models for various trip purpose. Later on these models are discussed at Town level for work and educational trips separately.

4.2 Data Requirement

To compare above estimated VOT (for congested region) with VOT for whole city more detailed data is required. This data should contain details of trips originating from all towns of Karachi. Trips details should comprise of travel time, cost, travel mode and journey purpose. Once this data is available then a map of Karachi can be plotted representing similar areas on the basis of VOT. Figure 14 shows the desired output stated above.

To collect such data, online survey software Qualtrics can be used to gather the required data. Online data collection method has been extensively used previously due to its advantages such as:

1. Cost effective and fast data collection technique.
2. Does not require interviewer to present during survey.
3. Survey can be distributed through social media and other links.
4. Questionnaire can be filled by respondent as per their convenience.

For current research, this method also has few disadvantages:

1. Only people having access to internet can be part of this survey.
2. Respondents are reluctant to share their Income range which can otherwise be predicted through Household Interview Survey (HIS).

Chapter 4 and 5 discusses mode choice preference and mode relevance with travel time through HIS data and questionnaire survey. A proposed GIS map as shown in FIGURE 14 is also developed for Karachi city from both the HIS data and questionnaire survey.

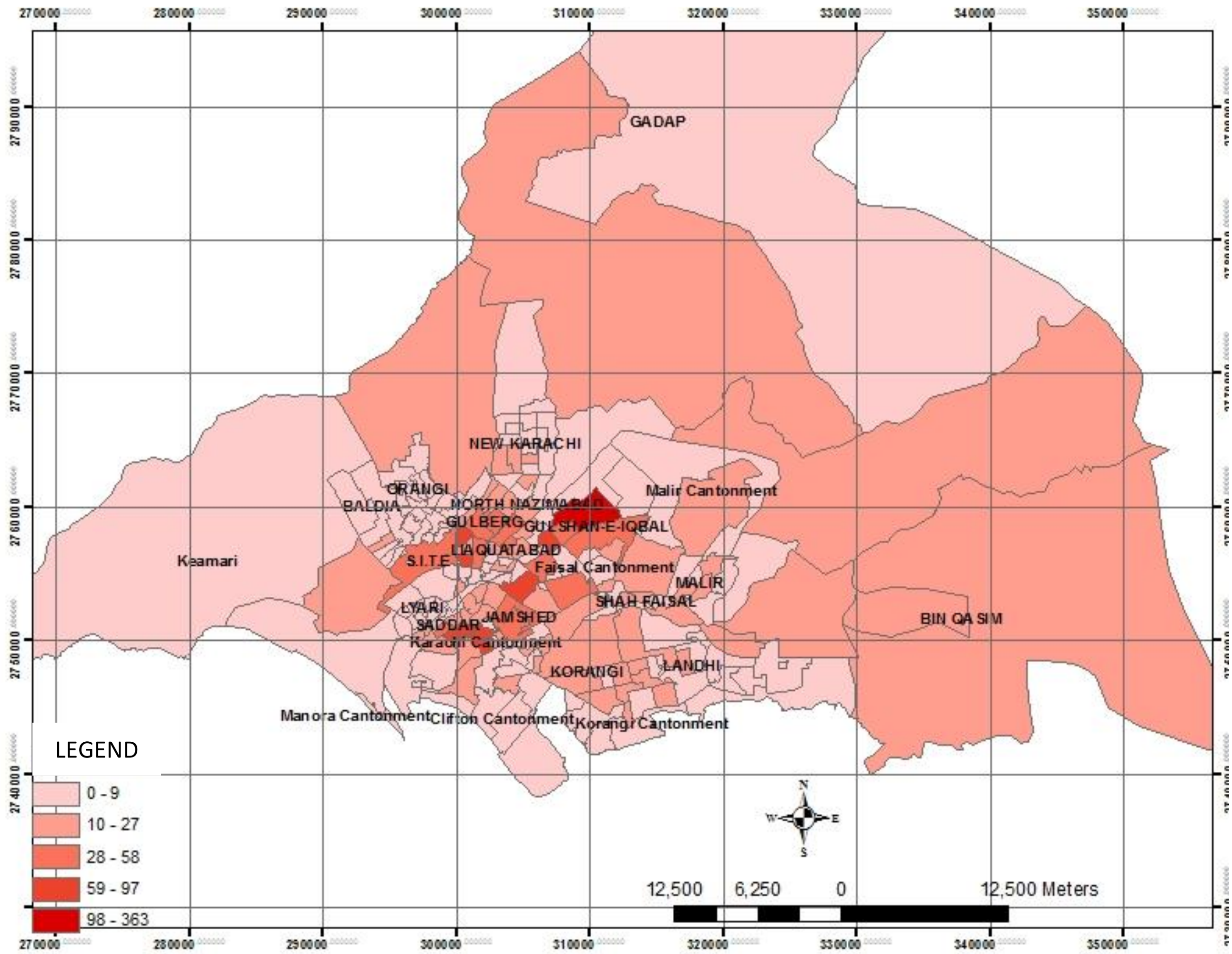

FIGURE 14 VOT Map of Karachi (proposed).

4.3 Household individual survey

The Household Individual Survey HIS for Karachi was collected by Japan International and Cooperation agency (JICA) as part of 'Karachi Transportation Improvement Project (KTIP) – 2030' project (JICA, 2010). This data was collected to capture the complex travel patterns at household level. The data comprises of socioeconomic background of citizen and their travel details at Union Council (UC) level. The whole Karachi city is distributed into 204 UC and 18 Towns besides 6 Cantonment areas. The details of the data are shown in Table 8.

TABLE 8 HIS 2010 Data Details.

Data Collected	Details
Household Interviewed	46,000
Individuals Interviewed	151,294
Total Trips	1,69,409

Figure 15 shows distribution of trips according to travel motives. Work trips constitute major portion of trips besides education which also has major share of trips. Besides, shopping, religious and visiting friend/relative has nearly equal share. Business and work trips were later merged together for analysis.

FIGURE 16 shows the number of trips made by individuals on a working day. It can be clearly seen that the large majority of respondents makes 2 trips per day. A smaller percentage of respondents also make four and six trips per day. In addition, a maximum of fifteen trips per person per day is also available in data. These respondents were having a blend of work related and social trips with majority of them having their own business setup.

FIGURE 17 shows the distribution of trips for individuals performing 2 trips in a complete day. It follows the same trend as of graph 1 (which is irrespective of number of trips per day). Due to significantly small dataset; business trips therefore work and business trips were combined for analysis.

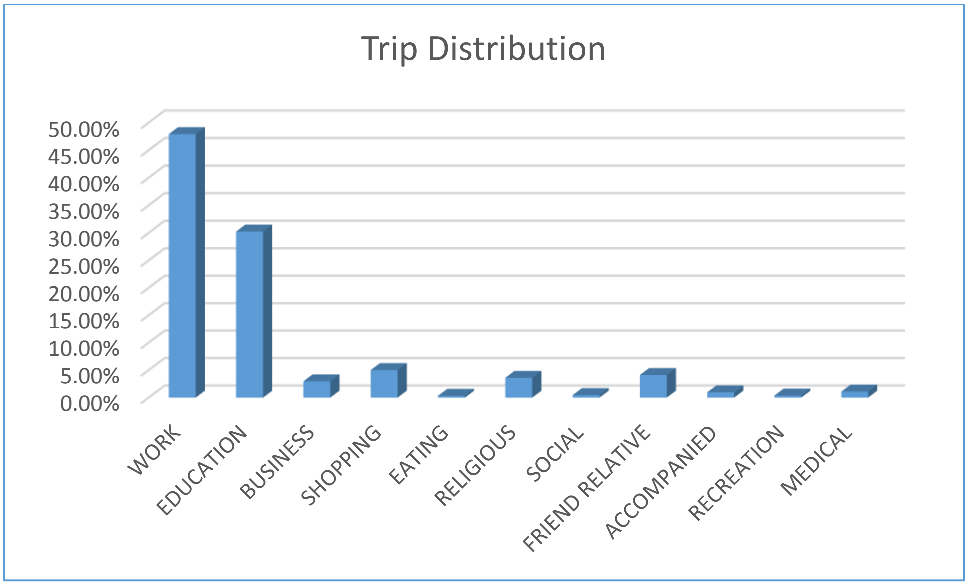

FIGURE 15 HIS purpose Distribution.

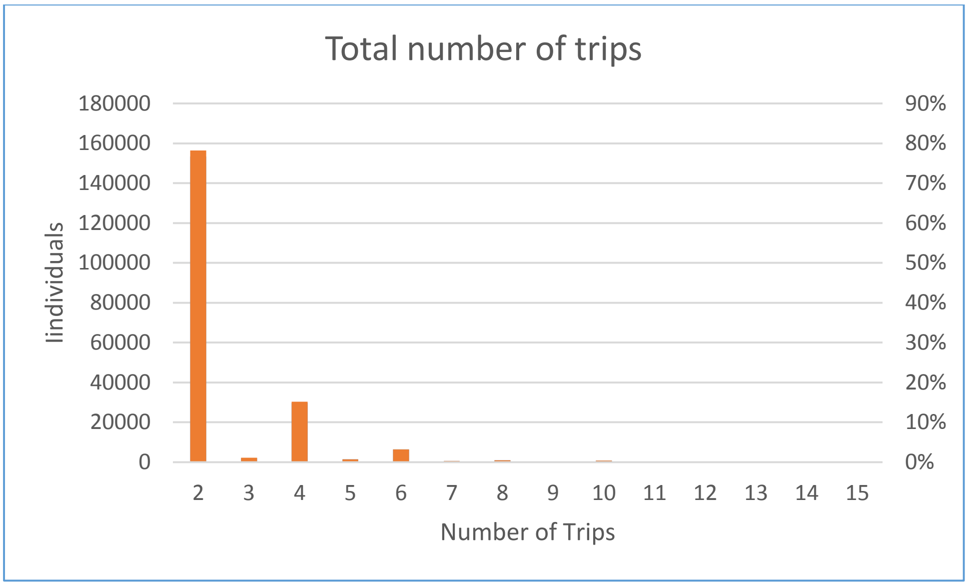

FIGURE 16 Number of Trips per individual.

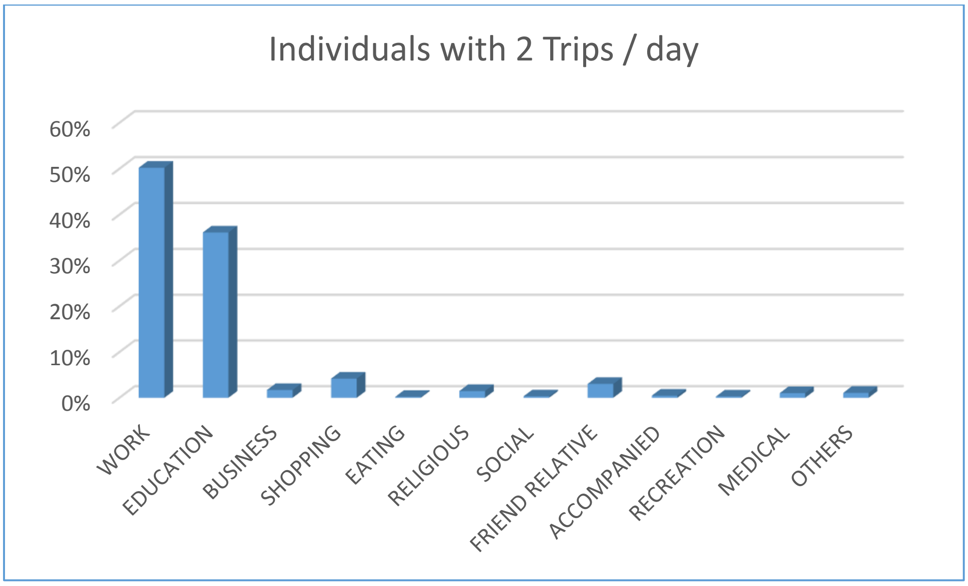

FIGURE 17 Trip purpose for individuals having 2 trips.

4.4 Data analysis

The data analysis was setup to incorporate the effect of travel mode, trip purpose, travel time and activity duration. Each of these effects were examined through a separate logistic regression model in SAS. The aim was to investigate the marginal change in Travel Time in relation to trip purpose and mode.

4.2.1 Travel Mode and Trip Purpose / Travel Time

The model for travel mode was developed through individual trips (N=194171) irrespective of trip purpose. Figure 18 below shows the distribution of these trips across travel mode. Non-motorized (NM) transport has the highest percentage of share followed by bus and bike (probably due to low travel cost). A number of para-transit modes such as taxi and van.

The logistic model was developed for travel mode against TT in SAS software.

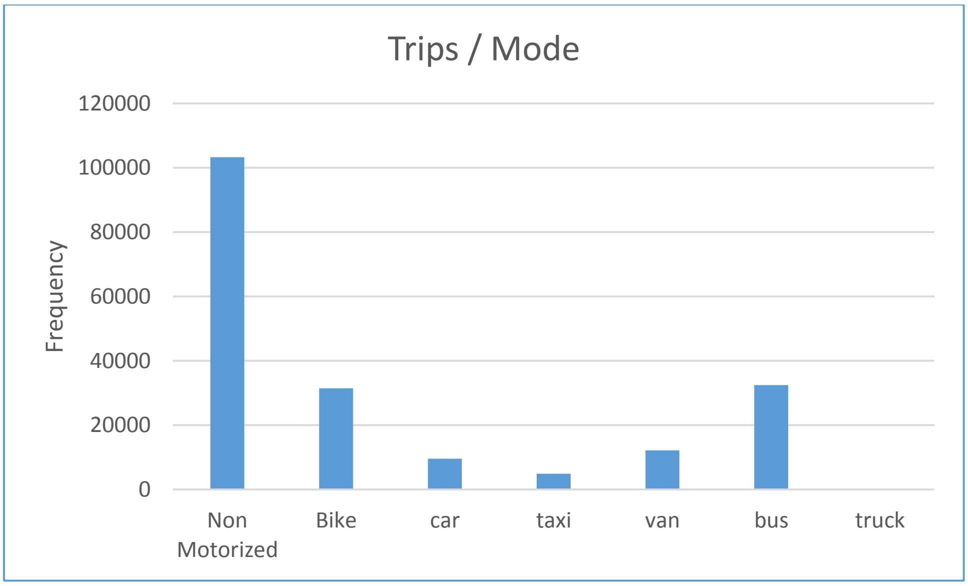

FIGURE 18 Frequency of Transport Mode.

The stimulus of transport mode was further analyzed with respect to each **travel purpose**, as done by researchers in the past. Table 9 below shows the number of trips and percent concordant of each model. Each of the model was fit to about 60% of data or above. Each of the observed parameters was found to be significant to the 99% level. Therefore, the results can be anticipated as rational upshots.

TABLE 9 : Logistic Model for each Trip Purpose (Mode / TT).

Purpose	N	percent concordant
Home	94810	70.5
Work	49612	67.3
Education	30656	67.9
Shopping	513	61.9
Eating	340	64
Religious	3306	67.6
Social	457	59.6
Relatives	4133	67.1
Accompanied	999	53.1
Recreation	409	62.8
Medical	1133	59.7
Other	3164	66.5

FIGURE 19 shows coefficient of travel time for trip purposes. The coefficient for travel time was obtained as part of each model mentioned in Table 2. β (Travel time), has negative sign as anticipated due to overall disutility of travel. However, it has maximum disutility for educational trips. The expansion of Karachi city has call people living in nearby villages' especially students due to ample amount of opportunities. However, there are a limited number of higher educational institutes in comparison to the area they serve. Certainly, on an average the distance and time for an educational trip is much higher as compared to conventional work or a shopping trip. There are number of shopping Centers near every localities; serving as Outer Business District (OBD), thus reducing the distance required to undertake a shopping trip. In addition to it, the amount of walking required is still high due to less parking stalls along with channeling of buses through parallel road. Therefore overall impact of shopping trip remains higher (in disutility) than work trips. If the work-place is at a far distance from current home; people usually shifts near their work place, as reported by Carolyn (Carlos Carrion, 2012).

Social trips (β=-51.56) also have reasonably less disutility as these trips are usually performed in vicinity areas. Unlikely to shopping are eating trips (β=-84.4). An increasing trend has been found over past few years for the initiation of chain of restaurants (also known as food streets) at both ends of the city. While one area offers beautiful view of seaside the other is located just outside the city boundary attracting people for a long drive, amount of fresh air and fairly inexpensive food. To add to it, equitably long waiting line at restaurants may validate higher value of travel time for eating trips than social excursions.

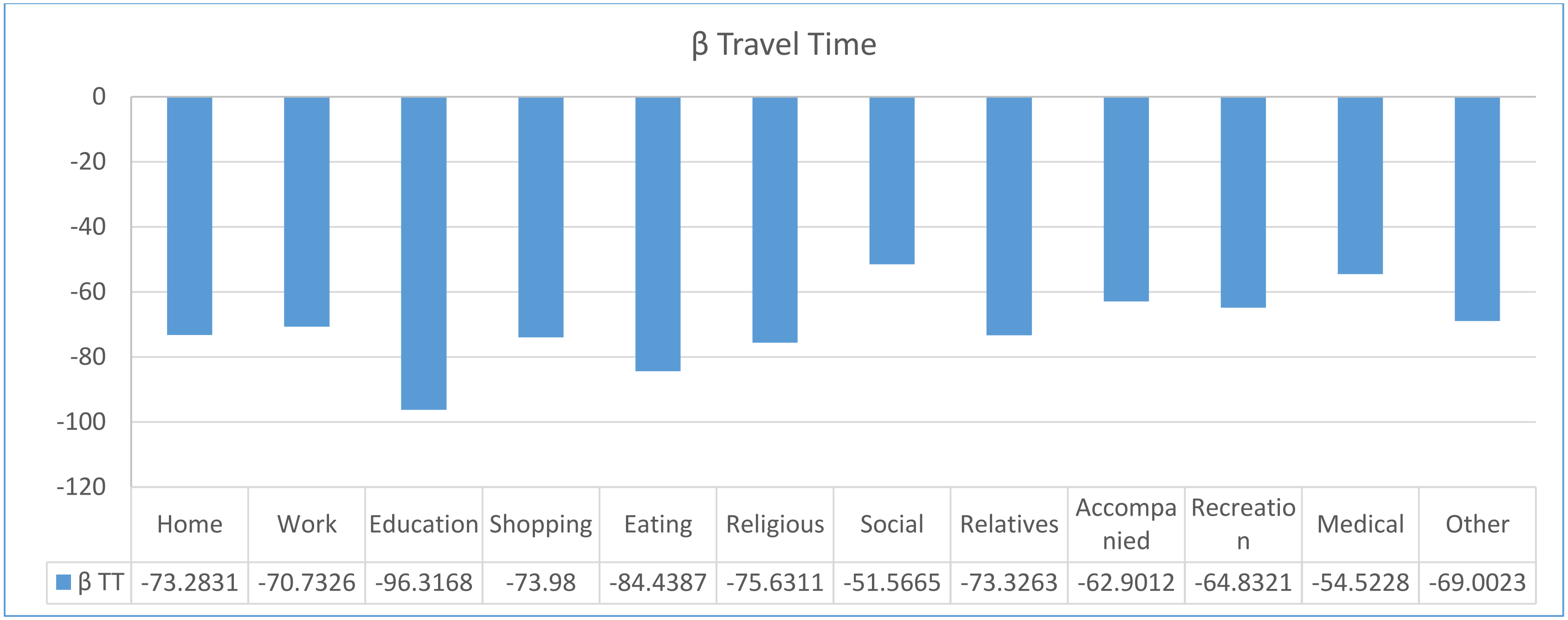

FIGURE 19 Modal Coefficients for Travel Time / Purpose Model.

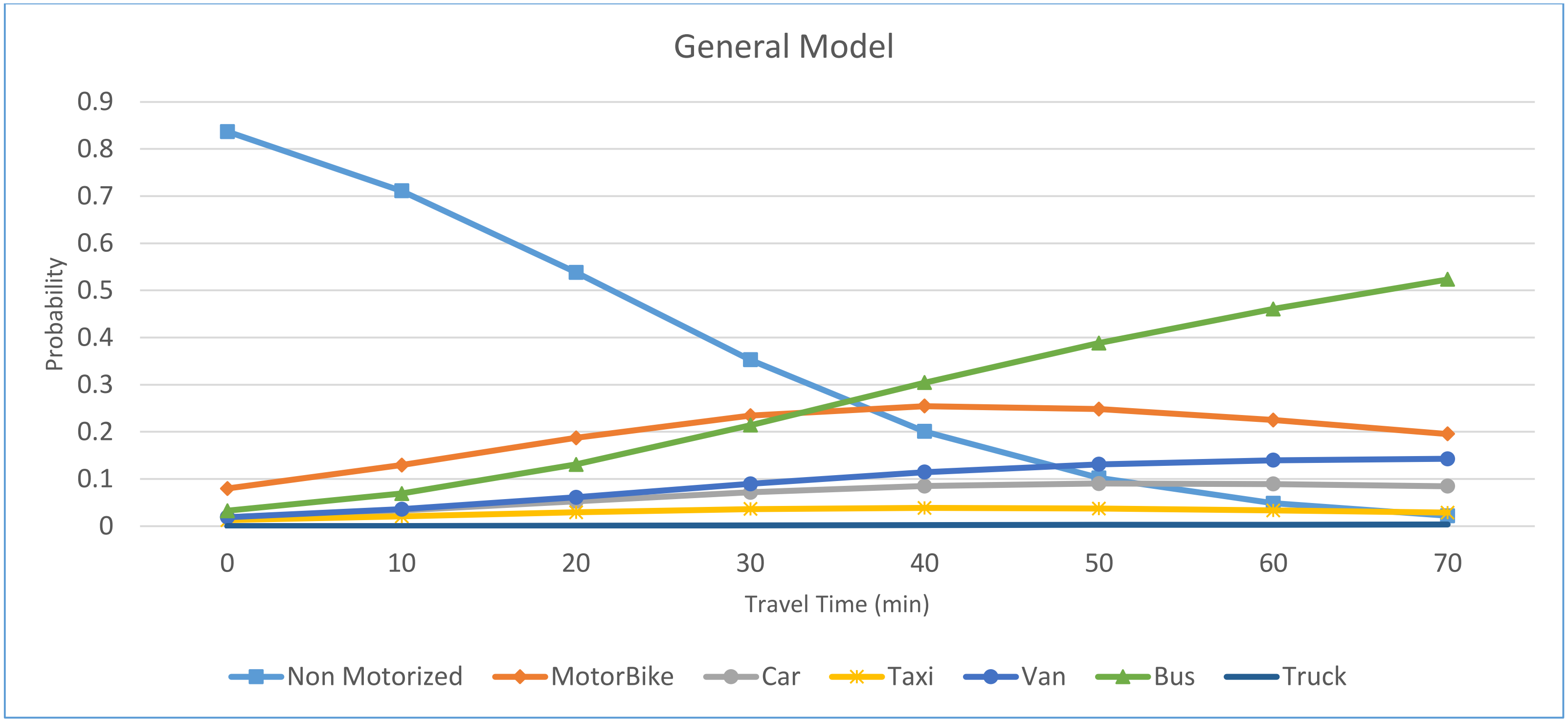

FIGURE 20 Probability of Travel Mode / Travel Time.

To better analyze the effect of travel time with respect to transport mode "Generalized Logit" model was developed in SAS. Besides providing the value of alternative specific constant it also shows the impact of travel time with each transport mode. FIGURE 20 shows the probability of using a particular transport mode with change in Travel time. It can be clearly seen the high probability of using non-motorized transport for shorter trips which reduces for trips above half an hour.

Buses being the only form of public transport attracts a large number of people therefore it has highest probability for usage at and above 35 minutes mark.

Similarly, bike is favorable for medium range trips (30 – 40 min) but it is not preferred for very short or even very long trips. This explains the low comfort and also exhaust factor constantly faced by motorbike riders. The interest in favor of car and van increase with an increase in travel time however van is more preferred than car for trips longer than an hour. The results also show a small percentage of people travelling through taxi for longer trips.

The probability of truck remains fairly constant irrespective of time which denotes to the fact that is used for freight transport and remains free from personal fondness.

To analyze the effect of travel purpose on transport choice separate analysis was done. There were in total 12 trip purpose available in the dataset. The models for each dataset showed 99% statistical significance of each parameter analyzed. The results obtained for SAS are shown in Appendix B. All these purpose are explained in detail in following section.

4.2.2 Home Trips

FIGURE 21 shows the preference of various available travel modes for home trips with respect to travel time. It can be seen non-motorized is greatly preferred over shorter trips and least preferred for longer trips. However, noticeable is the fact that it remains to be choice of masses even for 35 minutes longer trips hence a providing a intimation of low importance of saving time in comparison to other trip purposes (e.g. work and eating as shown in FIGURE 22 and FIGURE 25 respectively)where this slope is more steeper.

Correspondingly, Taxi (most expensive travel mode), has the least probability irrespective of travel time hence bolstering the fact mentioned earlier. Among motorized transport bike is most preferred for shorter trips whereas it is less chosen than bus for time-consuming excursions.

4.2.3 Work trips

Since the incorporation of travel purpose in valuing travel time, work trips are considered as the most important trip (De Serpa, 1971). This trend is also visible here through a number of visible features in FIGURE 22 such as higher probability of using bike even for shorter trips below 10 minutes. Moreover, non-motorized transport is mainly avoided after 30 minutes mark from where bus is the ideal mode. Around 50% of people avoid walking above 15 minutes of travel time whereas more than 70% prefer walking back to home at this travel time.

4.2.4 Educational trips

Educational trips are considered next important to work trips. FIGURE 23 validates this fact as the highest usage of van can be found for educational trips. Similarly, there are certain features that distinguish educational trips from other trips. A high percentage of walking trips and low trips by bikes are due to the fact that most students do not have driving license (or are underage to have one). Henceforth, around 80% of trips are covered by either bus or van even at above one hour.

4.2.5 Shopping trips

The trend for shopping trips is shown in FIGURE 24. These trips are conducted in close vicinity areas any even to main shopping centers far from residential area. Therefore, walking for shorter trips and usage of car and taxi for longer journeys is evident.

4.2.6 Eating trips

Eating trips are usually conducted at night by many individuals. This is also complemented by the fact that many restaurants opens around sunset till 4am. High percentage of walking in FIGURE 25 is for those trips which are done to nearby restaurants/ eateries hence having a smaller travel time.

In addition to this, recently two Food Streets have been developed one at the seaside (offering nice ambiance, seaside view and attracting business community) whereas other is located at outskirts of city attracting people due to its long drive and comparatively cheaper rates. An extraordinary high usage of private car and taxi for longer trips reveals the higher amount of visits to these food streets. These places are avoided by bikes therefore bike is only used for smaller travel time. Preference for car even at shorter travel time is due to societal setup as families (owning private car) prefer to avoid public transport and paratransit for social trips. This confirms that perhaps more wealthy people perform more eating trips, and they are more likely to have access to a car.

4.2.7 Religious trips

FIGURE 26 shows the trend for religious trips. The presence of Mosque in every area makes it accessible by foot. Therefore, 80% of the trips are performed by walking even at travel time of 20 minutes. Furthermore, trips above 1 hour are accomplished mainly by bike and bus.

4.2.8 Social trips

Social trips, as shown in FIGURE 27, reveal an overall different pattern. Vans are preferred by commuters to perform social excursion usually having higher travel time. Similarly, private modes are more utilized for shorter trips than longer trips. Reverse relation between walking and bus, as found in other trip purposes, holds valid for social trips as well.

4.2.9 Trip to Relatives

Visiting relatives is usually a quick and short trip hence compelling travelers to prefer private vehicle over public transport. Hence, bike and car are more favored for short and medium travel time. Similarly, shorter trips (to nearby areas) is undertaken by walking. This trend is shown in FIGURE 28

4.2.10 Accompanied by others

These trips, shown in FIGURE 29 are referred to those trips that are not performed alone. A company to another person possible 'reduces' the disutility associated with walking hence reducing walking disutility to a gentle slope with an increase in travel time. Irrespective of travel time bike and car also enjoys high share among other modes as two people can travel together on a single bike. Usage of van is relatively higher than for other purposes.

4.2.11 Recreational Trips

FIGURE 30 above shows trips for recreational purpose. Buses are certainly not the favorite mode to perform recreational activities. In comparison to it, private vehicle and van are usually suitable for recreation activities particularly for larger travel time.

4.2.12 Medical Trips

FIGURE 31 below shows trips for recreational purpose. Trips to Medical Centre in vicinity areas can be accomplished through walking however to distant locations is not preferable as they are conducted under emergency. Therefore, for smaller travel time walking is higher for medical trips however keeping in view emergency, private vehicle and taxi is also used for very small travel time. Medical trips are least performed in bus as compared to other trips executed through public transport.

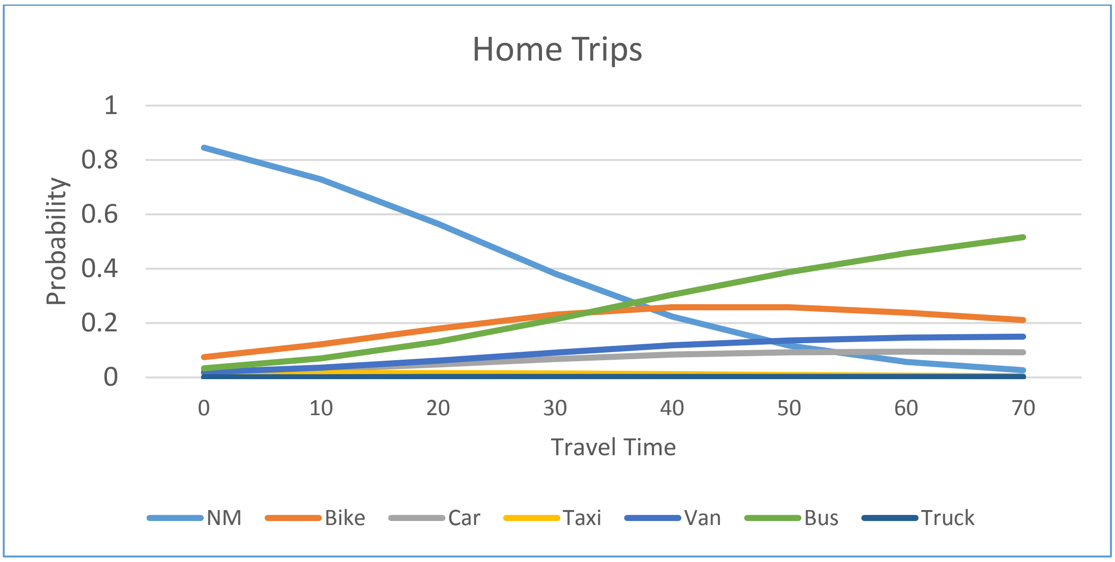

FIGURE 21 Travel Mode vs Travel Time for Home based trips.

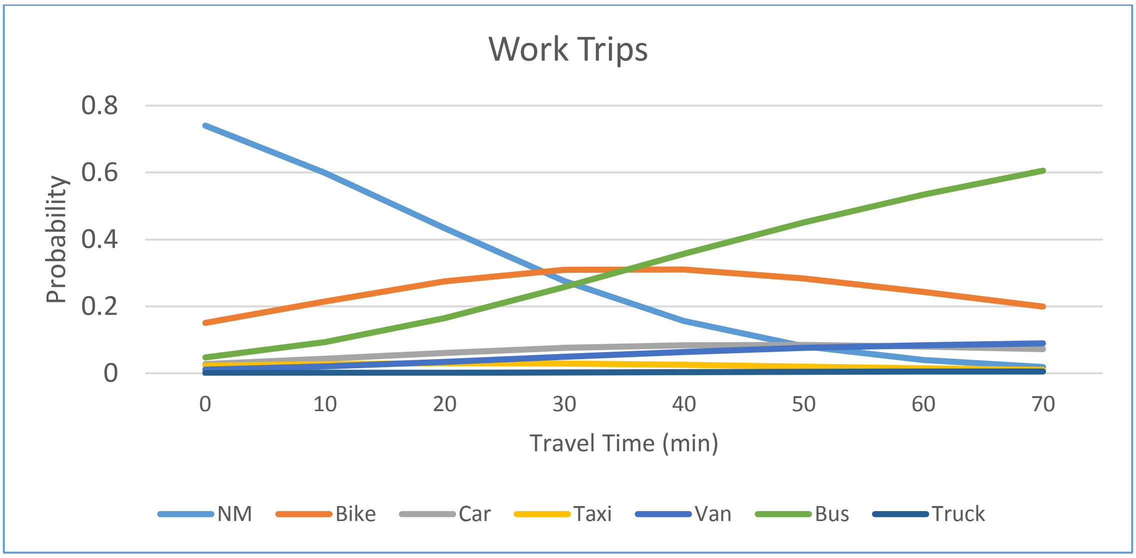

FIGURE 22 Travel Mode vs Travel Time for Work trips.

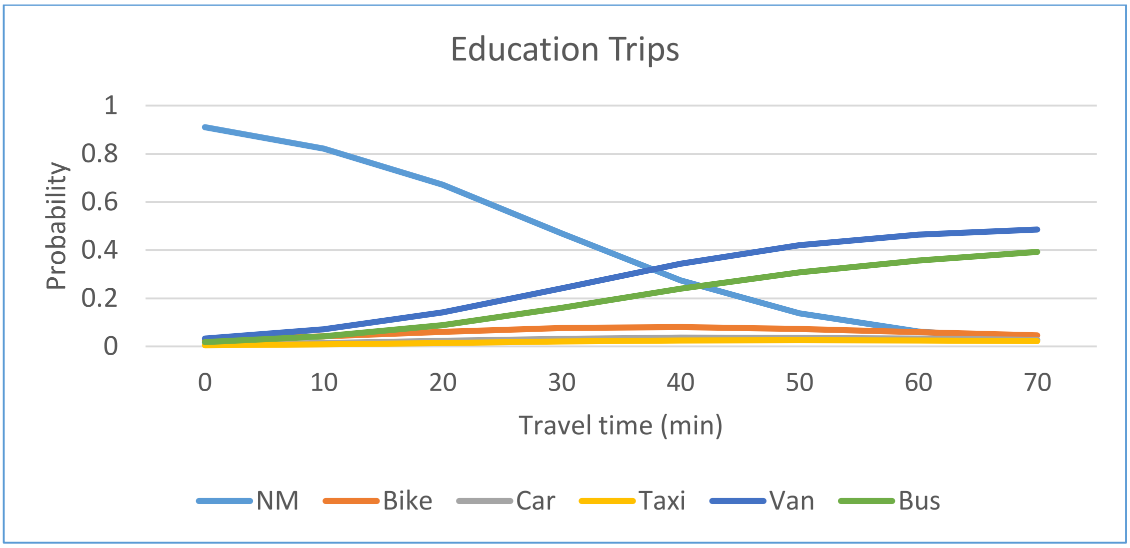

FIGURE 23 Travel Mode vs Travel Time for Educational Trips.

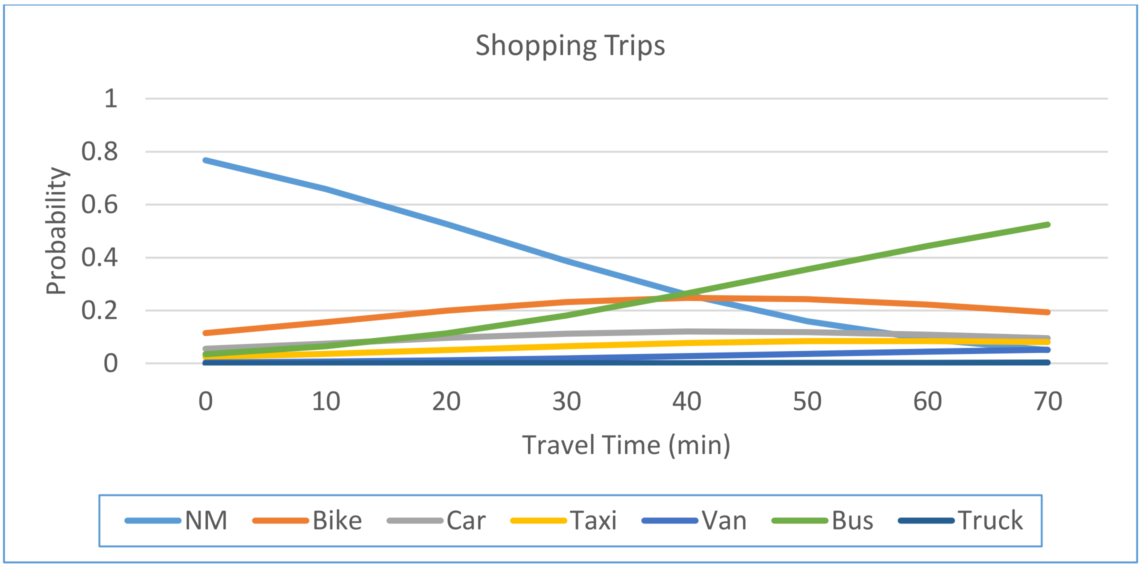

FIGURE 24 Travel Mode vs Travel Time for Shopping Trips.

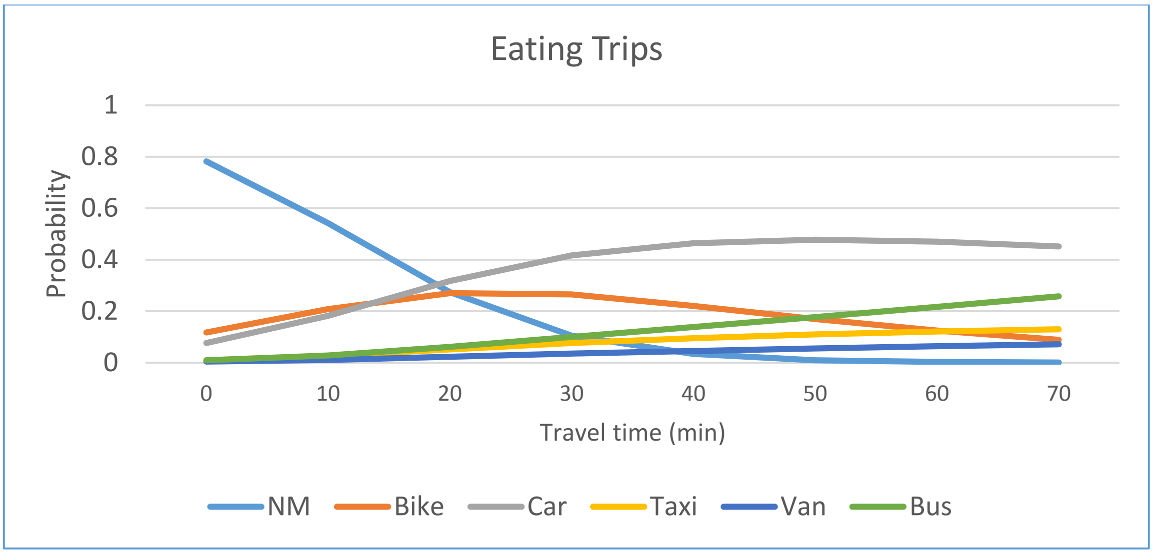

FIGURE 25 Travel Mode vs Travel Time for Eating Trips.

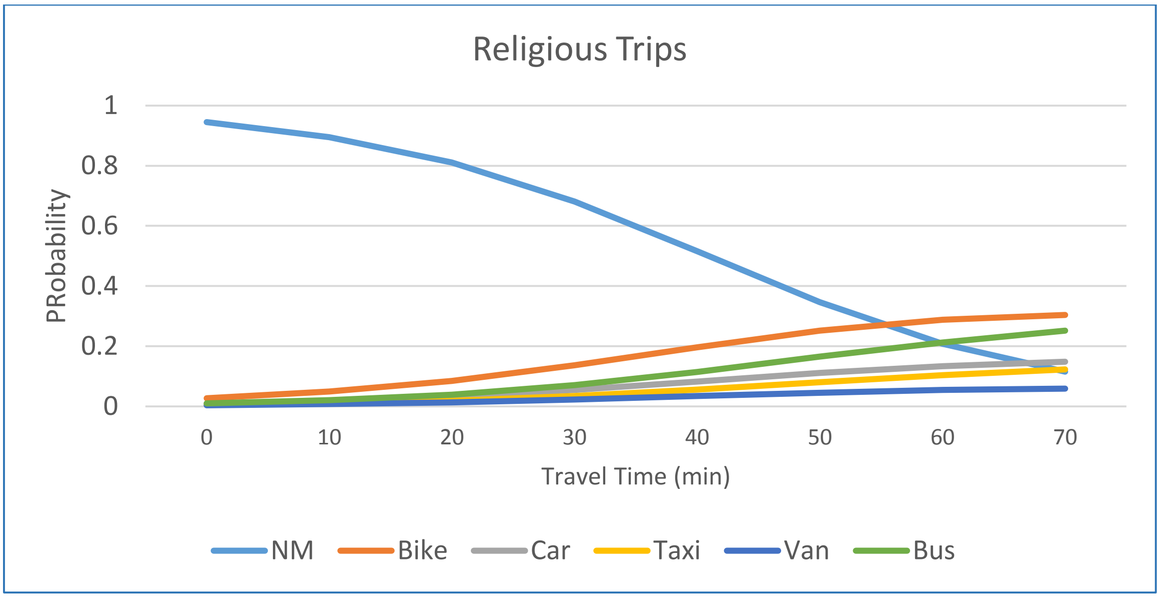

FIGURE 26 Travel Mode vs Travel Time for Religious trips.

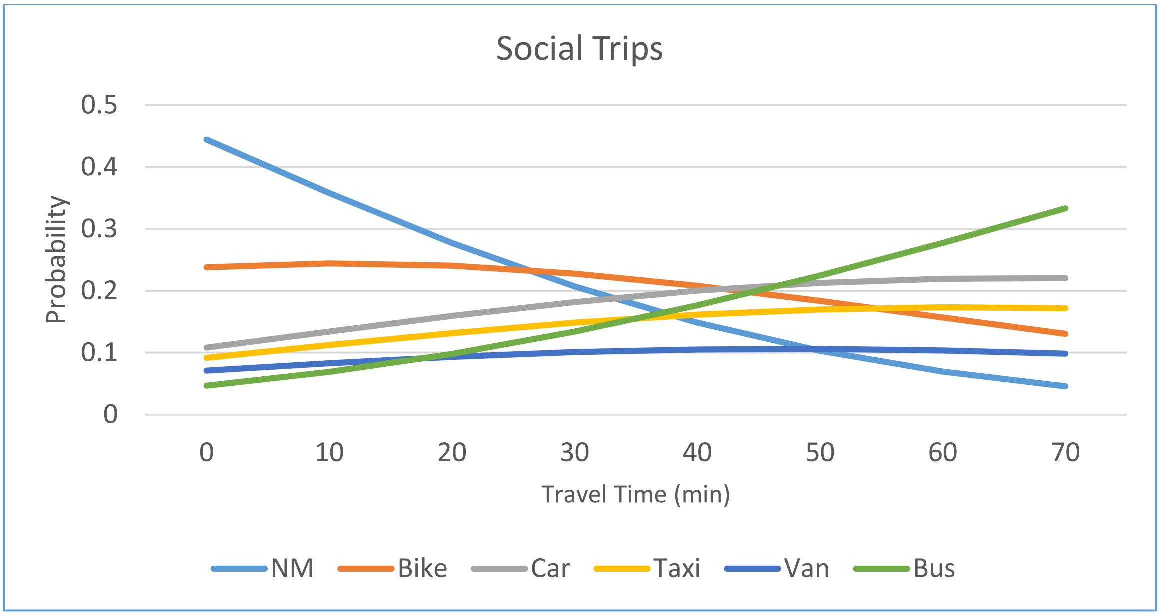

FIGURE 27 Travel Mode vs Travel Time for Social Trips.

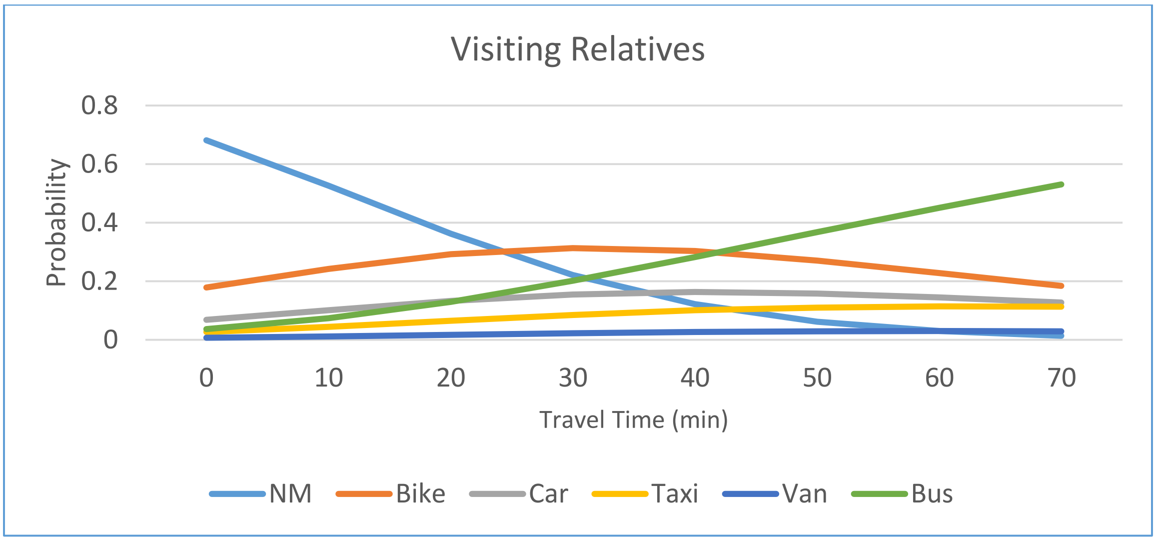

FIGURE 28 Travel Mode vs Travel Time for trip to Relatives.

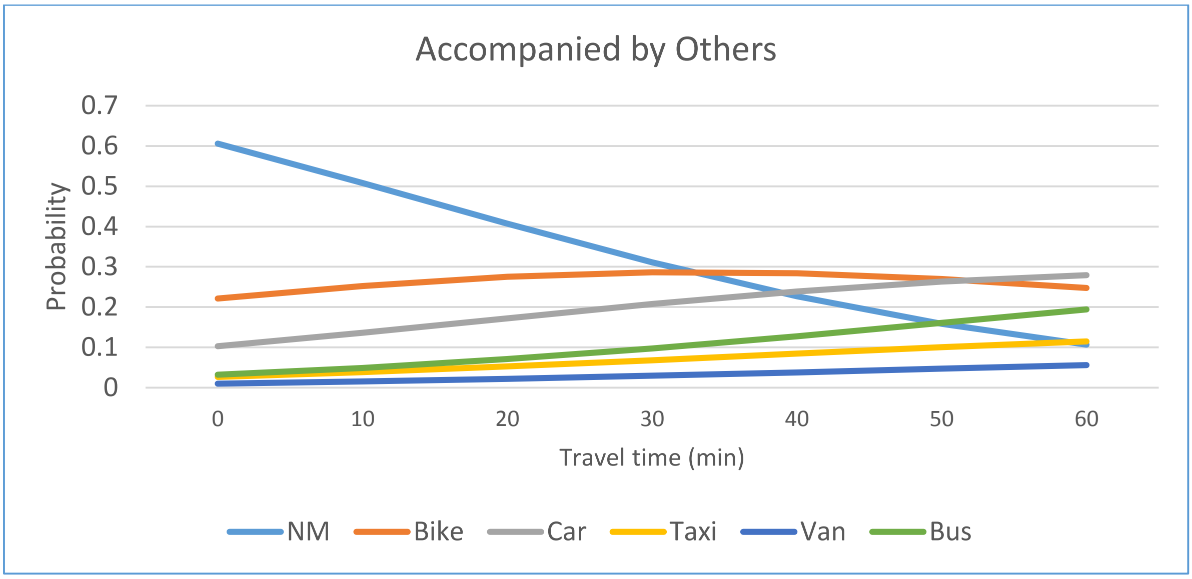

FIGURE 29 Travel Mode vs Travel Time for trip accompanied by others.

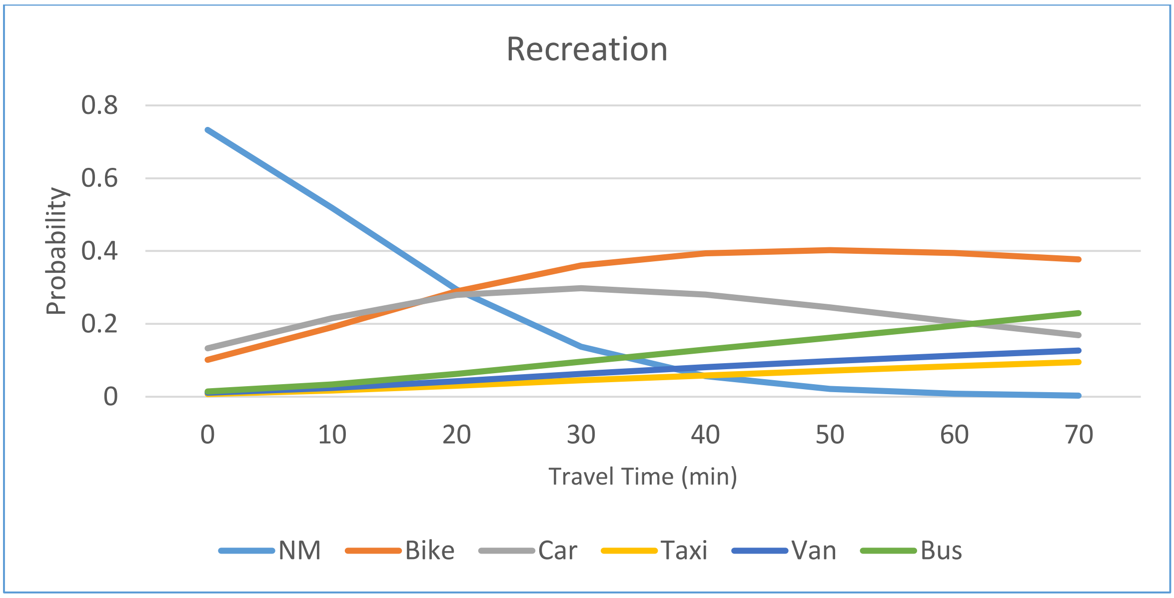

FIGURE 30 Travel Mode vs Travel Time for Recreational Trips.

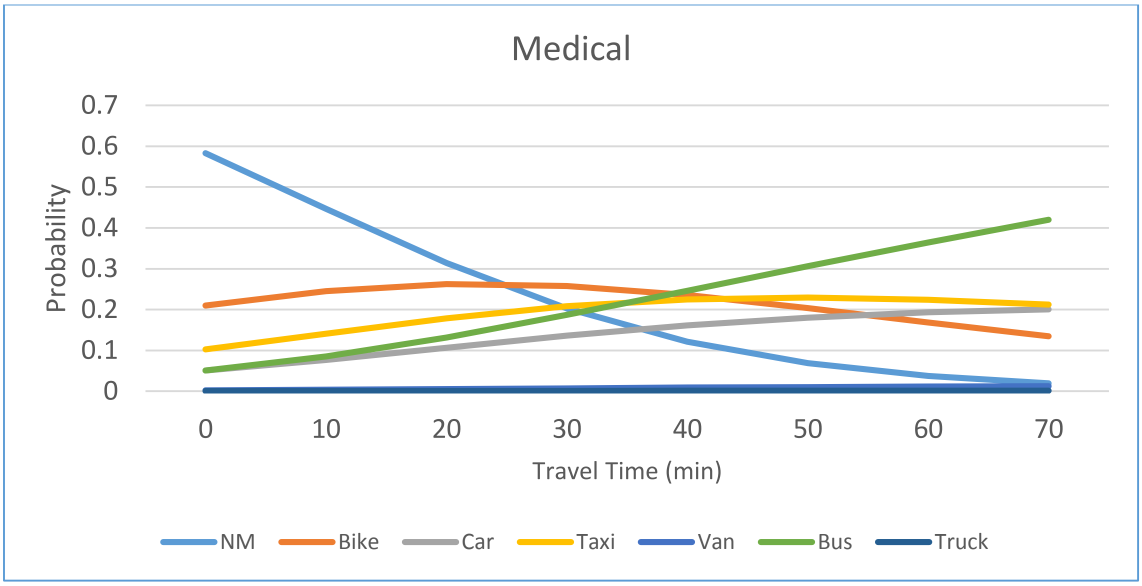

FIGURE 31 Travel Mode vs Travel Time for Medical trips.

4.5 Reflection

From the above graphs it can be easily concluded that for smaller travel time individuals prefer non-motorized transport (over other modes) for home, educational and religious trips. However, this trend is weakened for work eating, social and recreational trips. Public Buses are preferred for longer trips irrespective of activity type. Conversely, individuals owning car, like to perform eating trips by their, even for shorter distances. Motorbike is the second most preferred mode after walking and public bus for shorter and longer trips respectively. Vans are mostly used for educational trips followed by their appointment for social and recreational trips. Vans are commonly arranged for outings to farm houses located in city's suburbs, where people go to spend a night in solace.

Taxi, although being a costly mode, holds a high share of medical trips. This enlightens the importance for medical trips exclusively for families that do not own a car.

4.6 Town Wise Work Trips

A further detailed analysis was conducted to analyze the behavior at town level. Karachi city is divided into a total of 18 towns and 6 cantonment areas. There was a sufficient amount of data to develop separate models for each town. The explanatory and response variables were the same as in the model created before. The analysis was conducted in SAS through Generalized Logit models. The results clearly depict inter-modal disparity between different towns. The most distinct towns are discussed below (details of other towns can be found in appendix C).

FIGURE 32 below shows usage of transport mode for town 1 "Kimari Town". It can be seen that even Non-motorized mode is preferred by most even at a travel time of 40 minutes. Similarly the probability to use public bus increases with travel time however the probability to use motorbike remains relatively constant irrespective of travel time. This highlights the fact that those who own a motorbike desire to use it frequently. Nevertheless, the 'ease' of owning (available on small monthly installments), travelling (easier to maneuver in congestion) and parking gives motorbike the highest share among all transport modes.

Similarly, taxi and van have a small share of transport mode, which steadily increases with travel time. There is also a low likelihood to use car even at higher travel time. This certainly also denotes to a low car ownership ratio in Kimari Town. The probability to use Truck is fairly constant as it is used for freight transport and therefore it was omitted from later models.

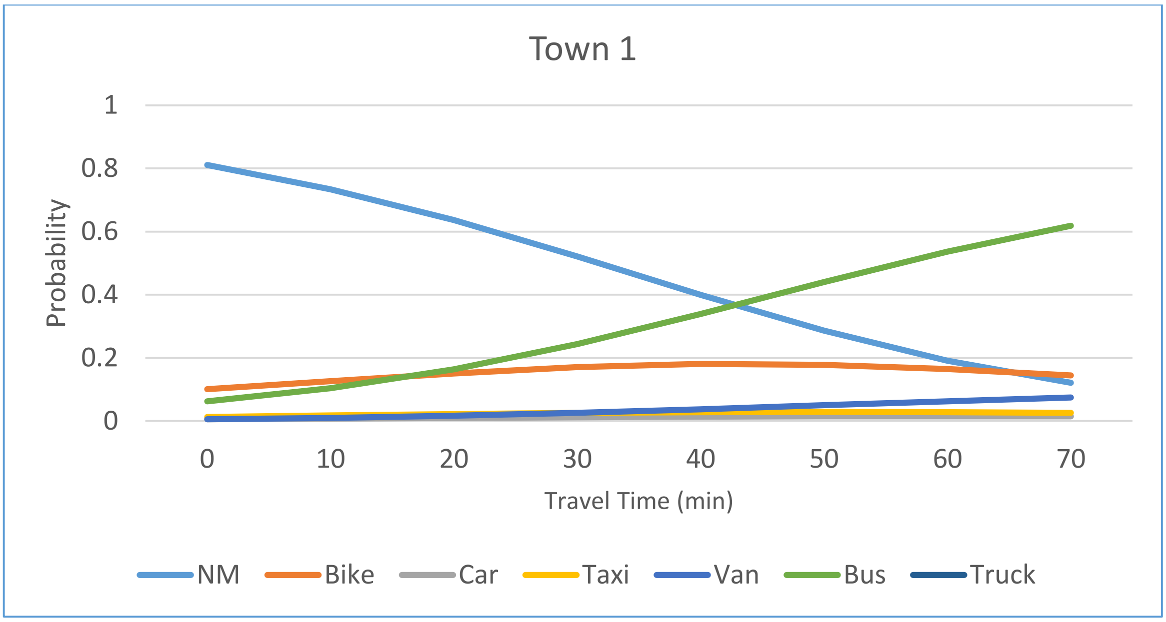

FIGURE 32 Probability of using specific Mode for Work Trips in Town 1.

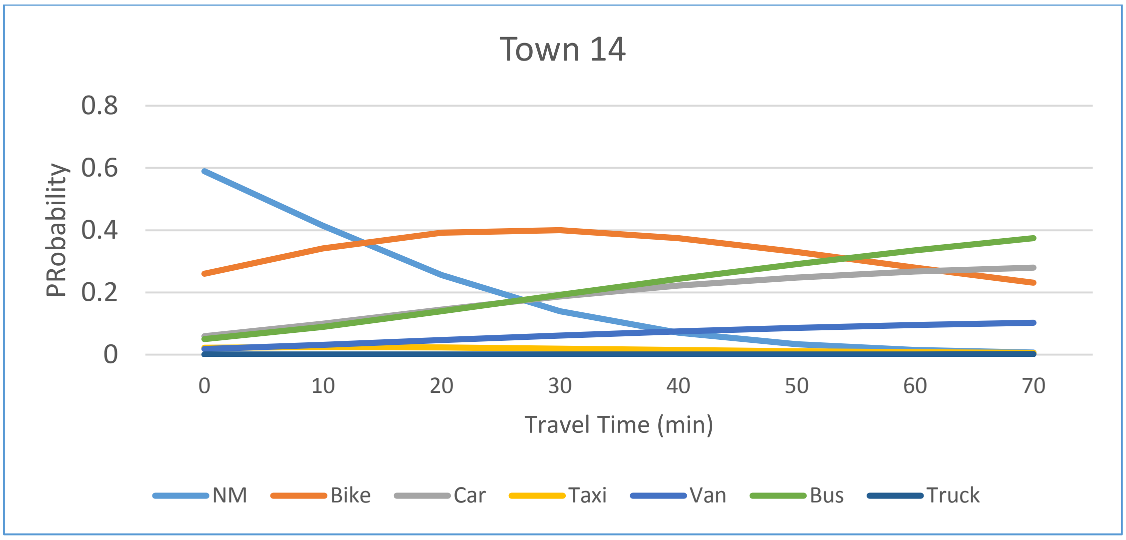

FIGURE 33 Probability of using specific Mode for Work Trips in Town 14.

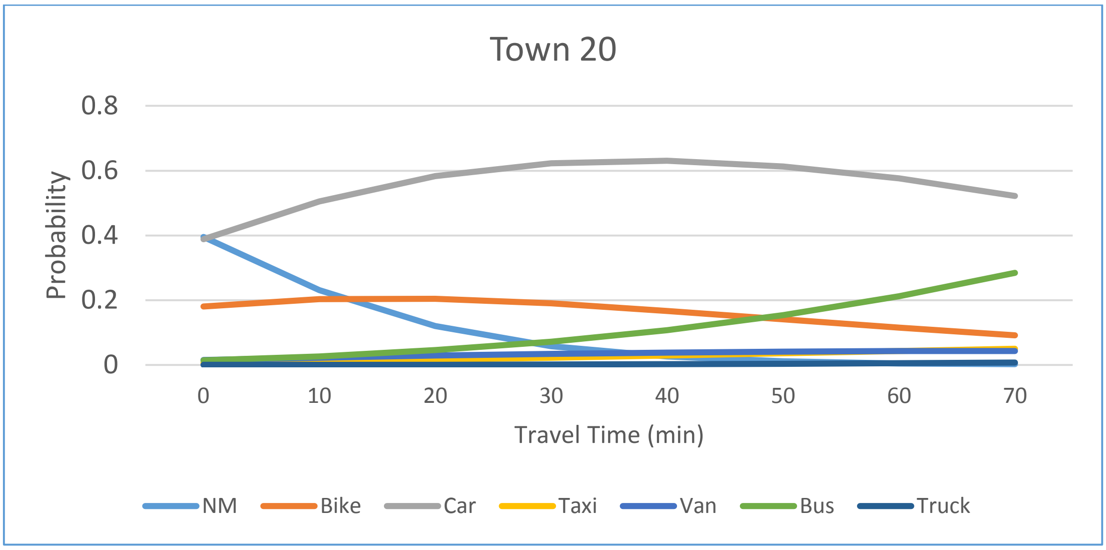

FIGURE 34 Probability of using specific Mode for Work Trips in Town 20.

FIGURE 33 shows the trend to use non-motorized transport falls sharply (with travel time) for Town 14 (Gulberg Town); unlike to that upward inclination seen for Town 1 in FIGURE 32. In addition, the probability to use bike remains highest between travel time of 20 to 40 minutes. Similarly the usage of bus, car and van increases with travel time with highest to lowest probability respectively.

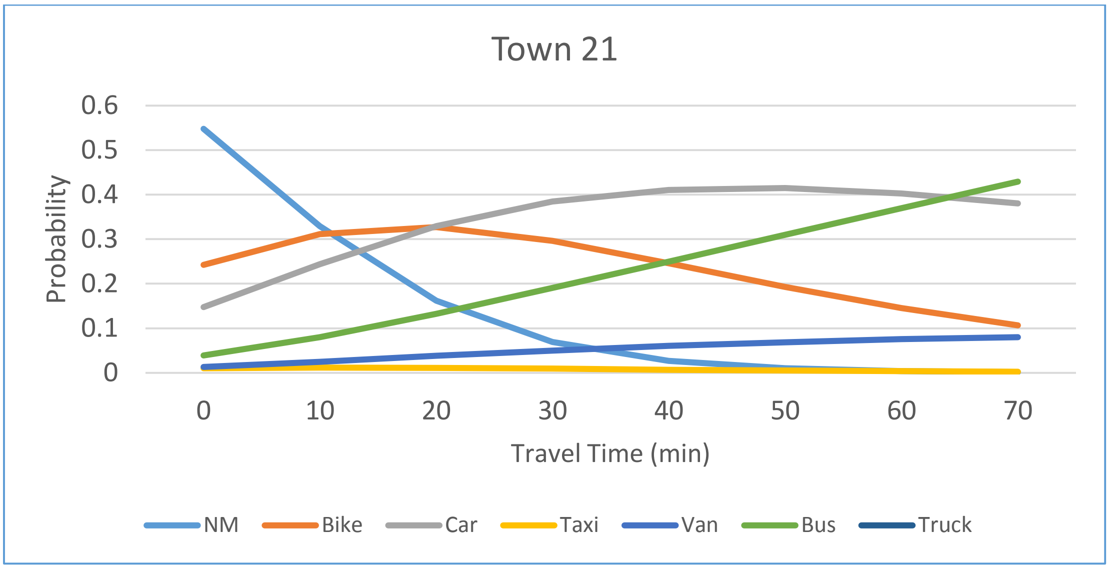

FIGURE 35 Probability of using specific Mode for Work Trips in town 21.

Gulberg Town can be termed as a prosperous area. This is also reflected from high usage of bike and car besides low tendency to walk to work places. Taxi, as in other town, is least preferred mode for work trips. There are numerous reasons to avoid taxi such as high cost, walking and waiting time. In addition to it, the high probability of owning a private vehicle also reduced the probability to use taxi.

FIGURE 34 shows modal split for work trip in Town 20 (Clifton Cantonment). Clifton area can be safely termed as (the most) wealthy area of Karachi city. It is the town where car has the highest probability regardless of travel time. The probability to use car is above 50% for trips above 10 minutes. Similarly, non-motorized transport is the least preferred mode for a trip just above half hour mark. Similarly a small percentage also prefer to use bus for buses above 30 minutes.

Faisal Cantonment is a Cantonment town which is operated by under Pak Army. It covers a small area with a number of spacious and mega shopping centers nearby at walking distance. It may be no wonder if people residing here go to these shopping centers via private car. FIGURE 35 shows the mode used by individuals living in Faisal Cantonment for work trips. It can be seen that probability of using car increases up to 1 hour after which it remains stable. Lowest share of taxi, along with high share of car, explains that every other individuals owns a car. Furthermore, a low share of van for work trips does emphasize that van facility is provided by companies for its employees however it is mainly avoided by 'Managers', 'Directors' and professionals drawing high income.

Mode choice for work trips was analyzed for each town. The trend for other towns can be seen in Appendix.

4.7 Relative Relevance of time

The models, discussed earlier, were separately created for each activity purpose to capture differences at town level. However, in order to compare the effects in-between towns it was necessary to create one inclusive model. Therefore another model was developed to model transport mode against travel time at town level, in SAS software. There was no cost parameter available in the data therefore the discussion in based on travel time sensitivity.

The below utility function was used to predict the relevance of travel time with respect to time.

$$U_i = \beta_0 + \beta_1 . TT_i + \beta_2 . T_i \tag{10}$$

Where,

U_i = Utility of Mode i (i= Non-motorized, Car, Bus, Bike, Van, Public Transport),
TT_i= Travel Time for Mode i,
T_i= Town coefficient for Mode i,
B_0= Intercept,
B_1= Coefficient of Travel time (1/min).
B_2= Coefficient of Town

Car is used as reference transport mode and Town 24 as reference town.

Town and Travel Time were used as explanatory variables while mode was dependent variable. Travel mode and Town were identified as categorical variables. The generalized Logit model was preferred over ordinary (binary) logistic regression for numerous reasons. Primarily there were more than 2 categories of both categorical variable and secondly generalized Logit identifies the effect of each categorical variable separately. In this case, the (β) coefficients were separately calculated with respect to each mode.

4.7.1 Work Trips

The model generated coefficients for travel mode for each town separately. These coefficients are shown in TABLE 10. The (β) coefficients for different travel mode now denotes weight allocated to travel time. This weight indicates the importance given by individuals to time with respect to each travel mode choice. This approach can accurately determine modal constraints to a high extent. Furthermore, this methodology also assist in determining the travel liking/disliking at Town level.

FIGURE 36 shows 'Relative Importance' of time spend traveling on Bike over car for work and business trips. It can be seen that there is huge difference between valuations associated by inhabitants of different towns. In addition to it, Town 6, 8, 20, 21 and 22 value time spend on car more as compared to bike. However, individuals living in other town value time spent on bike more positively than car time.

TABLE 10 Model Results for Mode / Town, Travel Time for Work Trips.

Name	Town	β Town NM	β Town bike	β Town car	β Town taxi	β Town van	β Town bus	β Town truck*
Kimari Town	1	1.734	1.3985	0	2.1294	2.2638	1.8342	1.5599
Site Town	2	1.1309	1.2908	0	2.0932	2.1483	1.631	10.6486
Baldia Town	3	1.0971	1.2466	0	1.565	2.19	1.8449	9.5861
Orangi Town	4	2.2987	2.5711	0	3.1089	3.2224	2.9059	10.6774
Liyari Town	5	1.7563	1.7068	0	3.2852	2.5108	2.3986	10.0402
Saddar Town	6	-0.6821*	0.1079*	0	0.1923*	0.389*	-0.4262*	7.7982*
Jamshed Town	7	-0.8941*	0.2225*	0	0.38*	0.9018*	0.0233*	7.9768*
Gulshan Town	8	-1.471	-0.7029	0	-0.4734	0.0628	-0.9001	6.1261
Shah Faisal Town	9	-0.616*	0.4573*	0	0.1366*	1.7224*	0.2371*	7.3854*
Landhi Town	10	1.1984	1.4971	0	1.9782	2.9269	1.8966	9.9766
Korangi Town	11	1.756	2.331	0	2.7791	3.3903	2.4549	9.0085
North Nazimabad Town	12	-1.4501*	-0.0341*	0	0.158*	0.5266*	-0.5278*	-0.8375*
New Karachi	13	-0.2696	0.6782	0	0.2554	1.2122	0.6728	7.7429
Gulberg Town	14	-2.0115	-0.5425	0	-0.8315	0.2779	-1.1212	5.2483
Liaquatabad Town	15	-0.6892	0.4717	0	0.8873	1.1673	0.2458	7.7092
Malir Town	16	0.6486	0.9805	0	1.4129	1.9732	0.8594	8.2048
Bin Qasim Town	17	0.6813	0.227	0	0.2424	2.5262	1.0041	9.0179
Gadap Town	18	1.3084	1.242	0	1.5953	2.0639	1.1225	10.4775
Karachi Cantonment	19	-0.6071*	0.1366*	0	0.6763*	0.7884*	0.4099*	-0.054*
Clifton Cantonment	20	-3.9238	-2.4219	0	-2.1981	-1.4693	-3.1504	5.3763
Faisal Cantonment	21	-3.0546	-1.4755	0	-2.2568	-0.5768	-1.7119	-7.2641
Malir Cantonment	22	-1.8259	-1.6453	0	-0.9294	-0.1696	-1.8727	-2.6296
Manora Cantonment	23	10.5928	7.494	0	10.1054	0.5191	5.1617	7.281
Korangi Cantonment	24	0	0	0	0	0	0	0

* Insignificant values

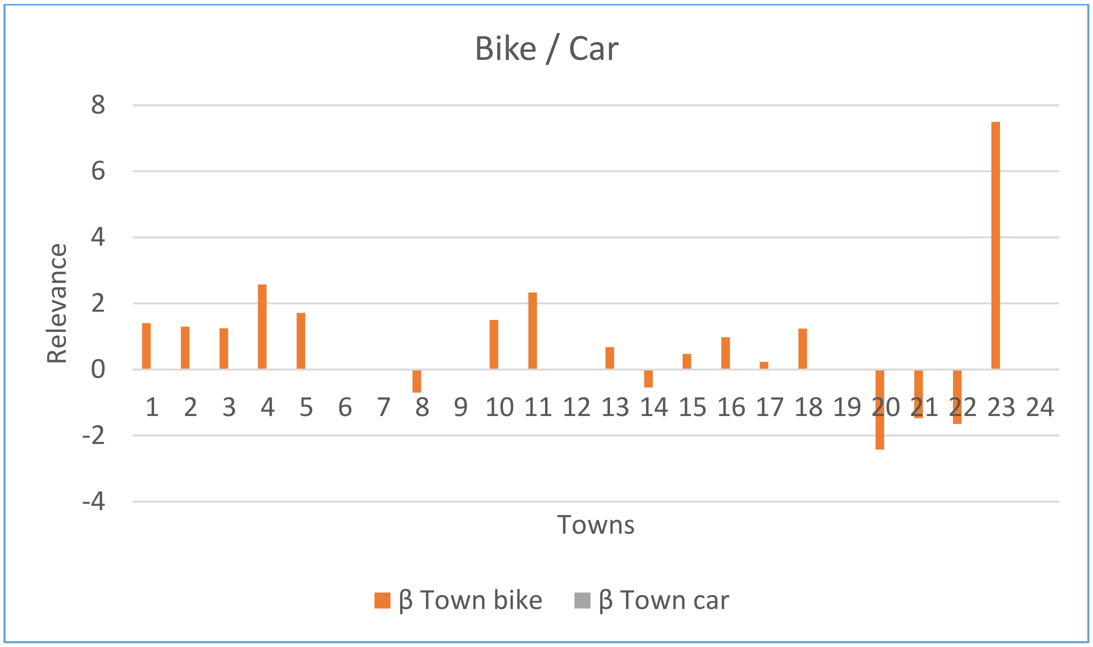

FIGURE 36 Travel Time Relevance for Bike / Car.

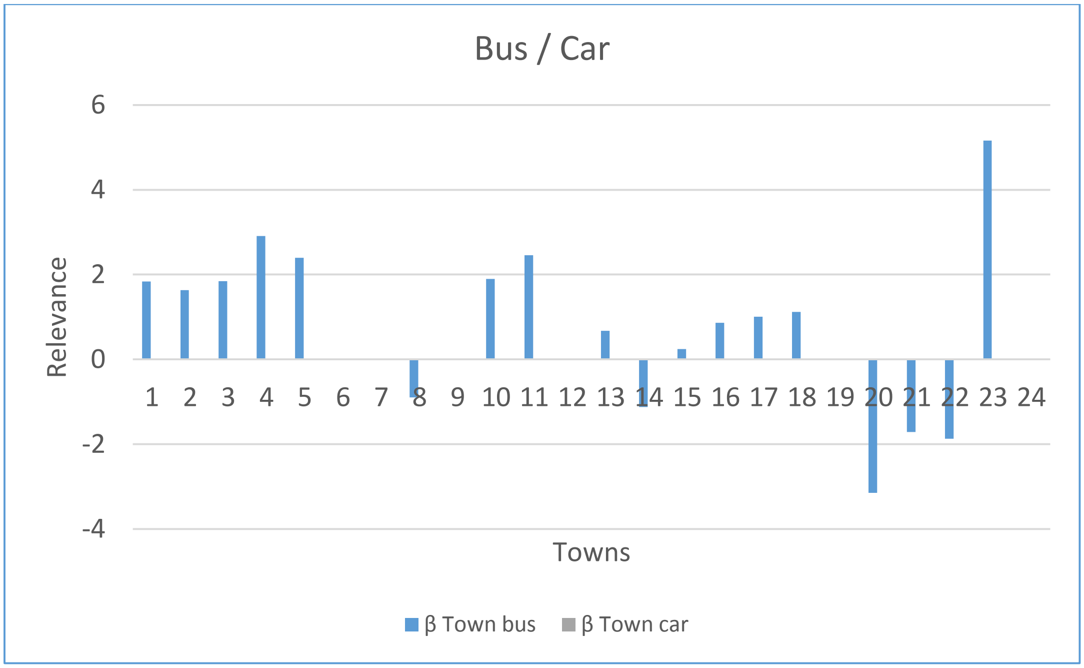

FIGURE 37 Travel Time Relevance for Bus / Car.

A very high value associated with Town 23 is also visible for other travel mode. This is perhaps because Manora Cantonment is located in Manora Island and most inhabitants are fishmonger to earn their livelihood. Similarly, residents of Town 1-5 earn relatively less income as compared to Town 7, 8 and 14. Therefore, a positive utility for bike majorly signifies absence of car ownership. Likewise, Town 8, 14, 20, 21 and 23 can be safely considered as wealthy and rich areas. Therefore, they value the 'car time' more than 'bike time'.

FIGURE 37 shows the importance of travel time spend in bus over that of spend in car. The trend is exact replica of that seen in FIGURE 36 for Bike over Car i.e. those who value bike over car also value bus more than car and vice versa. It is also noteworthy that the importance/unimportance is higher than bike. This implies that those who consider bike worthy over car also consider bus more worthy than bike. Moreover, those who prioritize car journeys over bike also consider bus less attractive than even bike. This former trend confirms the possibility of absence of any car (bike and bus valued higher than car), as told earlier while the latter endorses the presence of private vehicle and its associated disliking for public transport.

Moreover, an overall difference of up to three times (both positive and negative) can be seen in-between bike and car and bus and car.

FIGURE 38 shows the relative effect of each travel mode with car as the reference. The presence of car makes it most valuable mode followed by Van but for towns where car ownership is not very common; van have the highest values for travel time. Likewise least value is associated with non-motorized mode of transport that mostly comprises of walking along with a smaller share of bicyclists.

More interesting can be deviation in valuing bike. Although time spend on bike is more valued than walking, its relative position with respect to other modes fluctuates. For instance in Town 21 (Faisal Cantonment) people value bike more than taxi while people living in Town 22 (Malir Cantonment) have reverse preference.

An overall higher time/ importance for taxi is also natural. As people prefer to pay more for taxi only in case of certain emergency.

To get more insights FIGURE 39 shows inter-modal variations for Town 14 (Gulberg Town). It is visible that only van has slightly greater influence than car for work trips. Industrial area is also at distance from this town therefore travelers often use van service for work trips. An adequate number of buses connect this town to other areas thus buses are slightly less valued than bike.

It can now be established that Karachi city has diverse socioeconomic attributes of population that varies from town to town. Therefore, transport policies should be designed by this variation into account. For instance, placing an overhead pedestrian bridge and preparing roadways' median for pedestrian could have high importance in areas non-motorized transport is highly preferred. In comparison to it, pavement improvements can be focused on other towns.

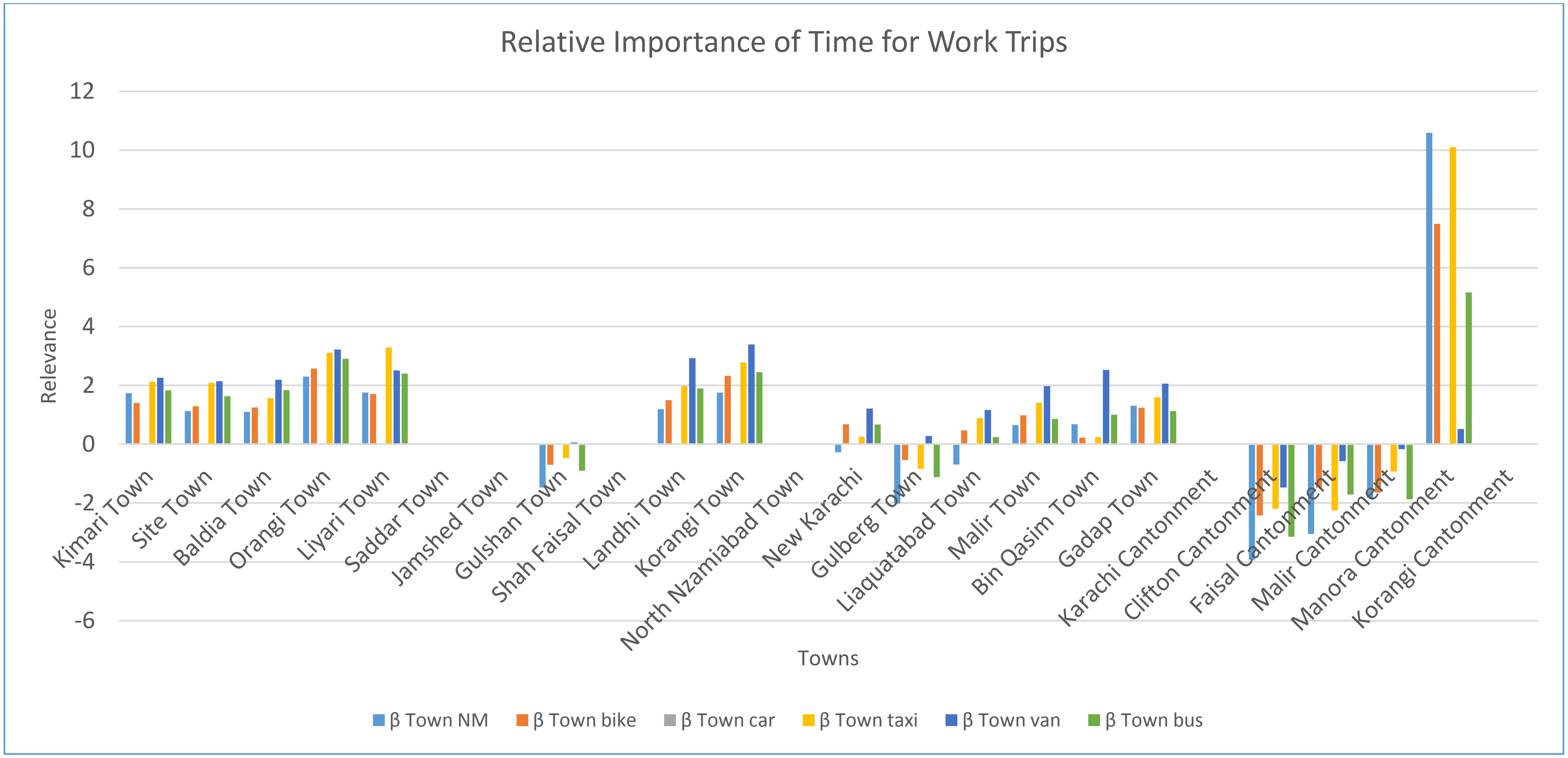

FIGURE 38 Relative Relevance of Travel Time with Travel Mode for Work Trips.

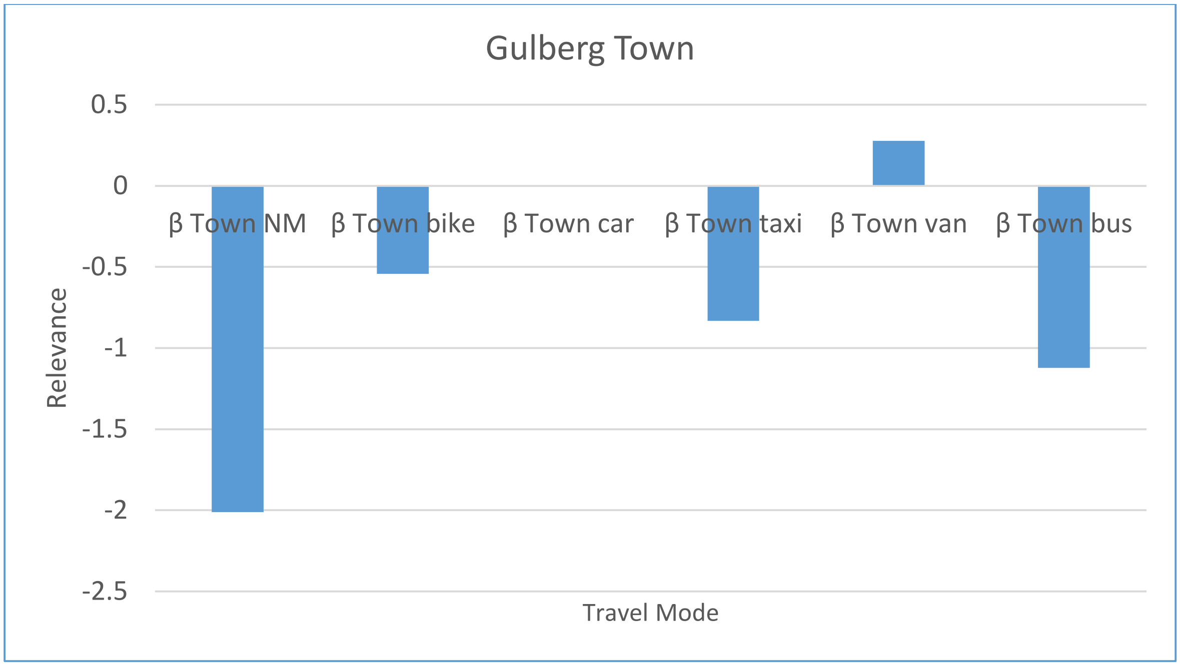

FIGURE 39 Modal Relevance in Gulberg Town for Work Trips.

4.7.2 Educational Trips

The results obtained from analyzing work trips proved to be much more realistic by distinguishing the travel behavior at Town level. Therefore, this analysis was also conducted for educational trips. Same explanatory and response variable were used as of previous model. Table 11 shows coefficients for travel time against travel mode. The values for 1 town were found to be insignificant and discarded from analysis.

FIGURE 40 shows 'Relative Importance' of time spend traveling on Bike over car for educational trips. Comparatively similar trend can be seen as of work trips. Except for Town 8 (Gulshan), 21 (Clifton Cantonment) and 22 (Faisal Cantonment) all value bike more than car. The same explanation may holds valid for this fondness. However, it can be noted that the highest value allotted to bike is 1 time whereas it was much higher to work trips. This is perhaps the reason educational trips are performed by students who have low importance of time as compared to working professionals. Contrary to this, there is more dislike towards bike for educational trips than work trips. A possible explanation can be youngsters like to travel in car (if available to them) especially in solitude. Besides, the availability of car also provides an option for carpooling to educational institutes. Besides being cost efficient for students it also serves as a source of pleasure particularly for longer trips. FIGURE 41 compares bus with car. Buses are always less preferred than bike for educational trips.

TABLE 11 Model Results for Mode / Town, Travel Time for Educational Trips

Name	Town	β Town NM	β Town bike	β Town car	β Town taxi	β Town van	β Town bus
Kimari Town	1	-0.1715	0.2519	0	0.0351	0.2767	0.1658
Site Town	2	-0.2147	0.2965	0	0.2599	0.275	0.4443
Baldia Town	3	-0.1042	0.1961	0	0.3154	0.2868	0.2252
Orangi Town	4	-0.1359	0.3823	0	0.1511	0.2816	0.4749
Liyari Town	5	-0.2957	0.2496	0	2.0365	0.2729	-0.00939
Saddar Town	6	-1.6967	0.1043	0	1.3457	-0.0194	-1.0978
Jamshed Town	7	-1.6661	0.4277	0	0.2077	0.3165	-0.5411
Gulshan Town	8	-3.4924	-1.7591	0	-1.6357	-1.2078	-2.2578
Shah Faisal Town	9	-1.245	0.3707	0	-0.2233	0.1083	-0.4669
Landhi Town	10	-0.2131	0.7551	0	0.6606	0.3863	0.3651
Korangi Town	11	-0.2158	1.0206	0	1.2927	0.3677	0.2017
North Nazimabad Town	12	-1.9997	0.175	0	-0.8677	0.557	-0.522
New Karachi	13	-1.2966	0.2683	0	-0.59	-0.0257	-0.2369
Gulberg Town	14	-2.9263	0.3148	0	-1.5918	0.376	-1.2424
Liaquatabad Town	15	-1.3957	0.4412	0	0.3717	0.2815	0.0173
Malir Town	16	-0.439	0.5881	0	0.484	0.354	0.1847
Bin Qasim Town	17	-0.5177	0.0299	0	0.8134	0.0648	0.2473
Gadap Town	18	-0.2775	0.4072	0	0.4451	0.1792	0.5372
Karachi Cantonment	19	-1.332	0.1813	0	-0.7511	-0.0577	0.2565
Clifton Cantonment	20	-17.791*	-15.2235*	0	-15.6074*	-15.2383*	-17.22*
Faisal Cantonment	21	-4.2565	-3.0212	0	-2.8805	-2.1844	-2.9644
Malir Cantonment	22	-2.4946	-1.3407	0	-1.9085	0.8997	-0.116
Manora Cantonment	23	-0.1396	0.00347	0	-0.00901	0.6426	0.3348
Korangi Cantonment	24	0	0	0	0	0	0

- Insignificant values

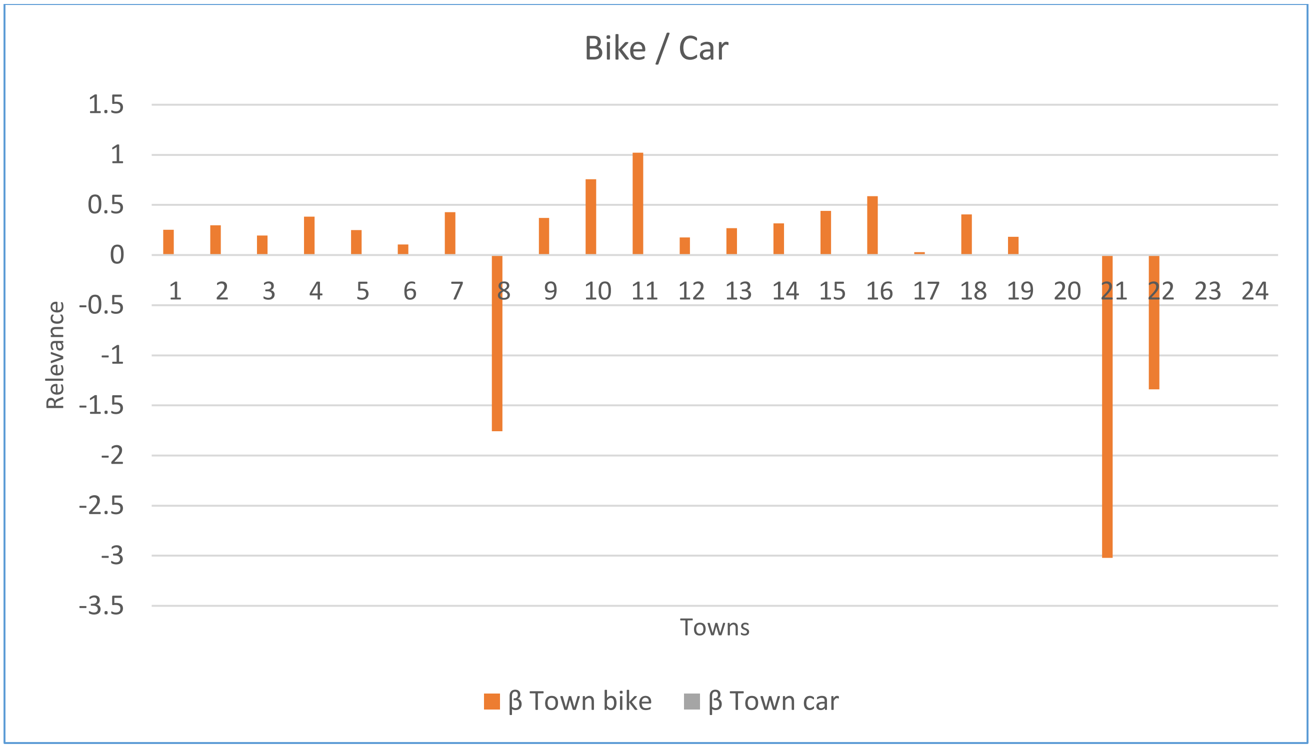

FIGURE 40 Travel Time Relevance Importance for Bike / Car – Educational Trips.

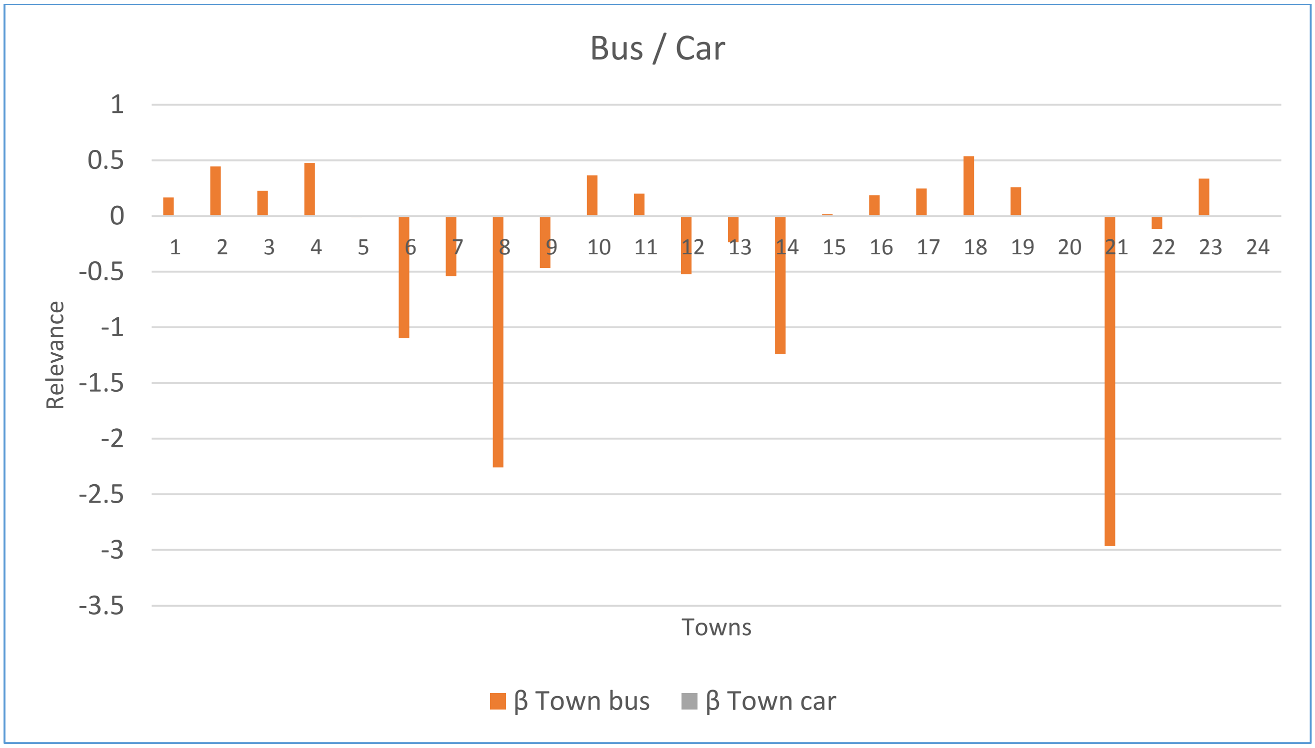

FIGURE 41 Travel Time Importance for Bus / Car – Educational Trips.

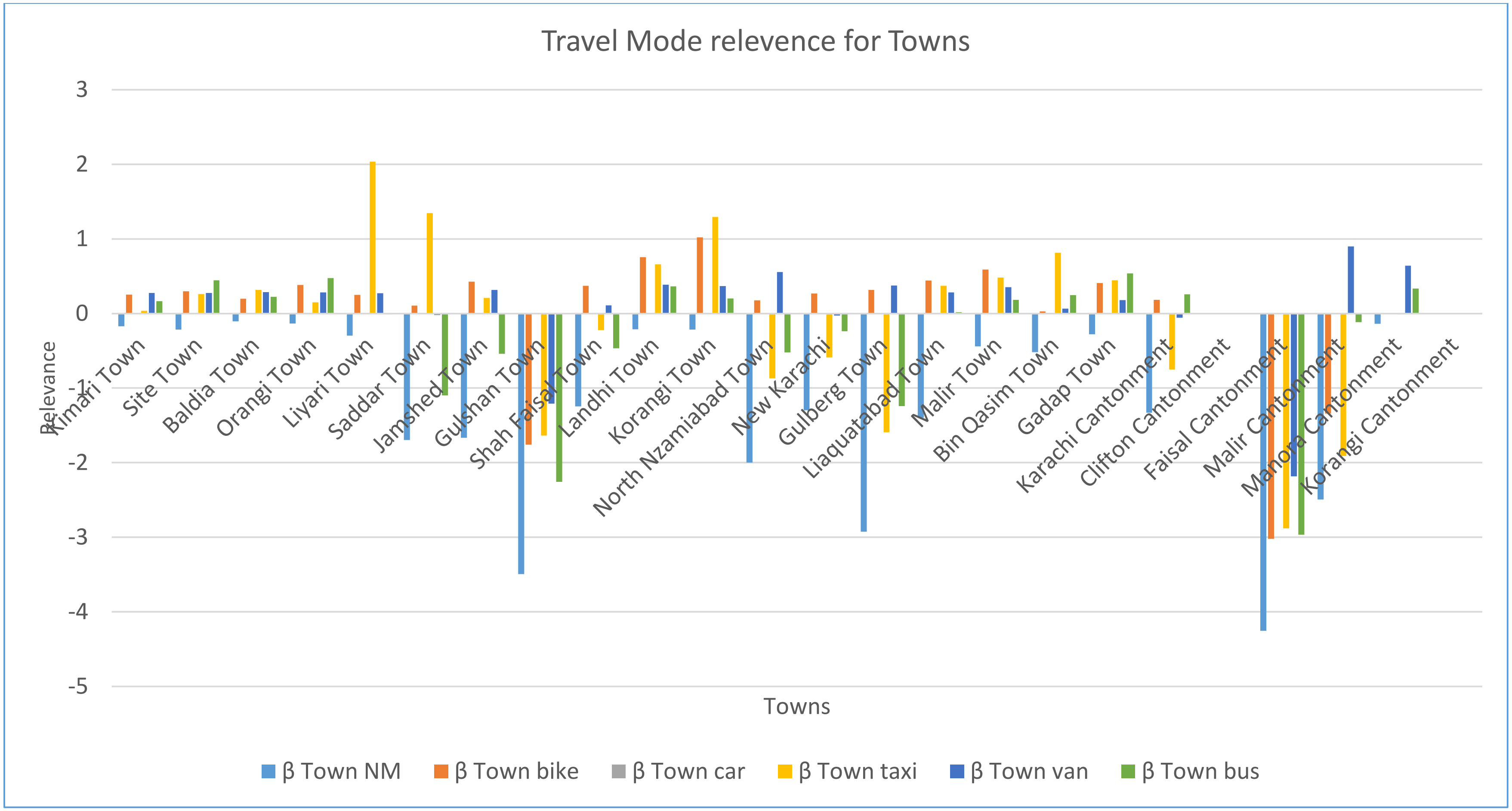

FIGURE 42 Relative Importance of Travel Time with Travel Mode for Educational Trips.

FIGURE 42 illustrates liking of each mode for educational trips. The effect at Town level remains comparatively same as of work trips. However, trips conducted in taxi have the highest importance for educational trips. Taxi has been an effective mode (in absence of car) for educational trips as the fare (to be paid monthly) can be divided between each commuter (student). In addition to it, as each student has to be picked from a different location thus adding up total travel time and increasing its prominence. Lastly, educational institutes also has a 'fix start timings' after which students are not allowed to enter inside the premises therefore the 'time pressure' also adds in increasing its importance. Similar to taxi, are conventional van which are more common for both educational and work trips. However, the passenger carrying capacity of van is much higher than taxi which have both its advantages and disadvantages.

A very high abhorring attached with walking speaks about the Higher Educational Institutes (University/ Colleges) which are, although as compared to rest of the country, limited in number. Each university has a relatively large campus and serves around 4000 to 10000 students. A majority of students do not have access by walking unless they live in nearby localities or student hostels (located inside the campus).

To further explore this trend FIGURE 43 shows mode variation in Town 14 (Gulberg Town). It is evident that bike and van have more importance than car. Tendency of providing high value to van being already elucidated earlier, higher importance for bike reveals its availability and affordability (as a travel budget for educational trip is lower than work trips).

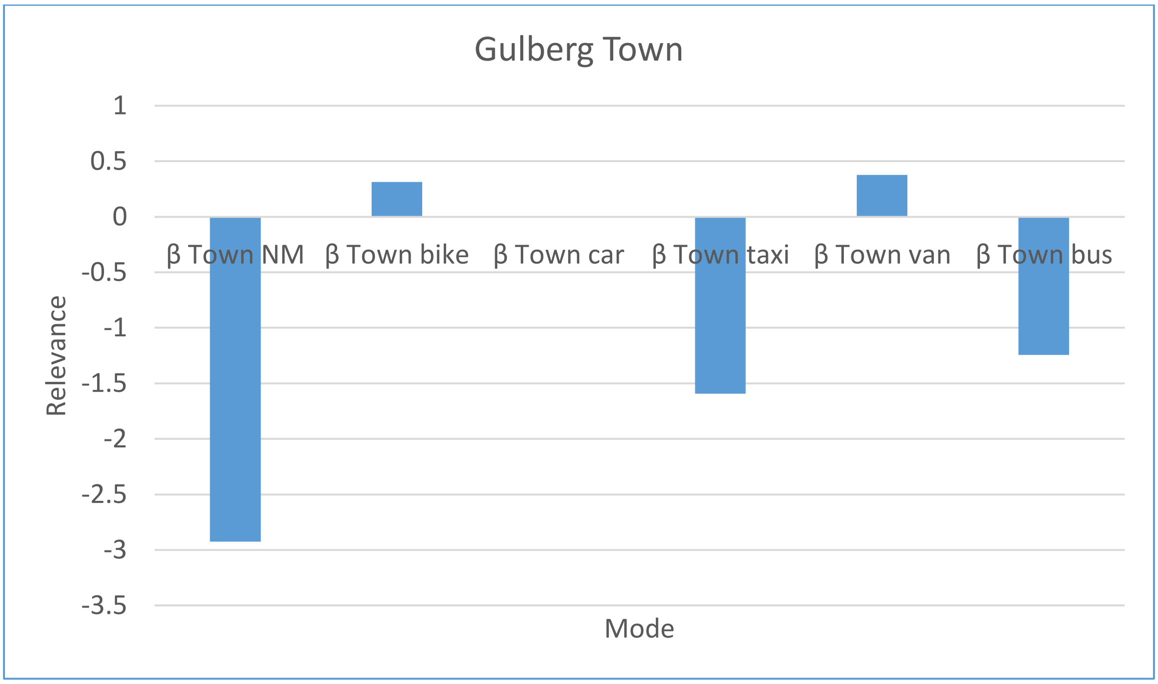

FIGURE 43 Modal Importance in Gulberg Town for Educational Trips.

More thought provoking is the negative influence (as compared to car) towards Taxi. This effect is opposite as compared to majority of other towns. Perhaps, this points to the presence and availability of car for educational trips.

Contrasting to trend for work trips, buses are valued higher than taxi for educational trips. The bus fare remains same irrespective of town of 'origin'. However, unlike to it, Taxi drivers can ask for fare as they 'want'; which mostly take into account social status of commuters. Therefore it is quite possible that residents of Gulberg Town are charged very high amount keeping in amount the trip undertaken thus making taxi less realistic than bus.

4.8 Variation with Trip purpose

It has been already established that mode preference does vary at Town level. The next step is now to identify the trend concerning trip purpose, if any. FIGURE 44 below represent this propensity as in Town 14. The most common difference is of motorbike which has negative and positive relationship with car for work and educational trips respectively. Referring to **Error! Reference source not found.** n Appendix C where probability to use motorbike is shown; the probability to use bike remains highest below 50 minutes. Keeping this in mind, work trips can be higher than 50 minutes or even higher (to some industrial area), whereas travel time for educational trips typically remains less thus making bike trip more practicable.

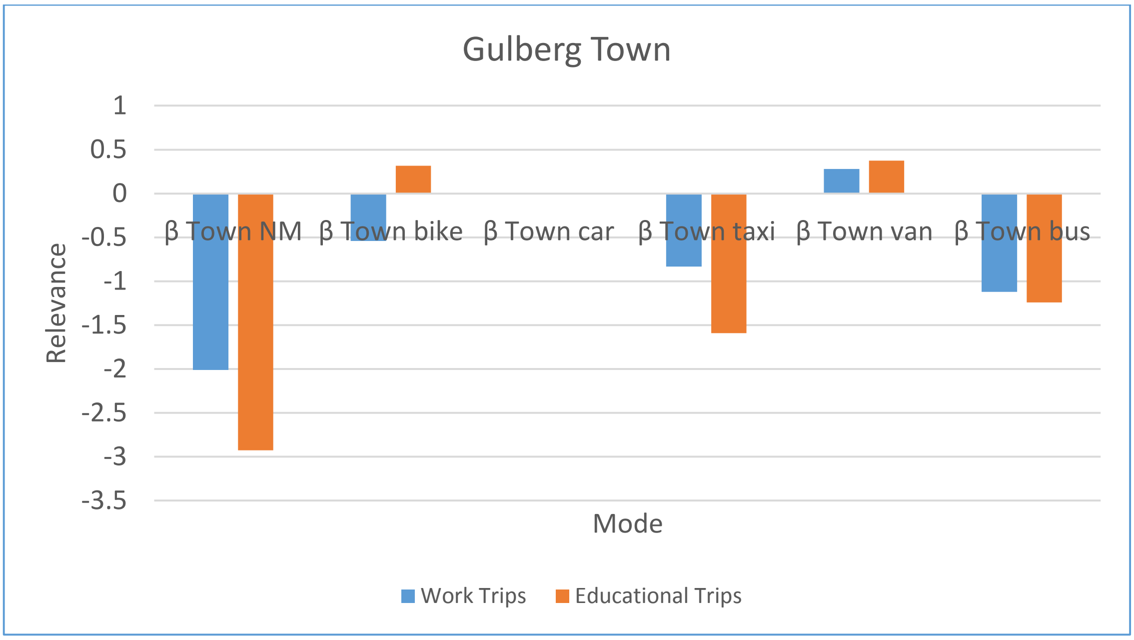

FIGURE 44 Mode Preference for Work and Educational Trips.

4.9 Practicality of this approach

Mode choice models were used to assess the relevance of time. However, the availability of cost parameter in future may allow to estimate VOT at Town level.

The values obtained above can provide a detailed insight to individuals' travel preference. Besides underlining the dilemma that a general choice model can never be 'valid' for whole city due to its mix socioeconomic setup it also signifies how transport mode is termed as an emblem of social status. This tactic can be effectively implemented to envisage how commuters perceive travel based on their social restraints.

Furthermore, the analysis above proves that the activity purpose has a major impact on mode choice based on the attributes associated with each mode. For instance, within a zone, the relative importance of one travel mode over other varies with activity purpose keeping all other parameters constant.

The explanation provided above has been based on work and educational trips. This examination can be extended to all trip purposes available in the data set. Based on the robust results obtained above, expecting assorted trend for other activities will not a false expectancy. Moreover, the incorporation of departure time and travel budget (as a fraction of income) can also lead to thought-provoking results. Discussion on GIS Maps prepared from these results is in the following section.

Chapter 5: Spatial Analysis of Travel Time Relevance

5.1 General

In the previous chapter the influence of travel time against travel mode was shown. Current chapter is based on the discussion of GIS maps created from the graphs discussed in previous chapter.

Once the relative values of travel time have been identified the following step was to transform the results achieved into a GIS thematic map. These maps can show the complete behavior at a glimpse, are rich in information and are predominantly much easier to understand. Correspondingly, the comparison of two maps can also lead to the identification of all differences separating them, if any. Besides, the map also gives a brief understanding of geographical setting. It can be seen that each of the town are quite different in terms of spatial setting, area, social and economic setup.

These maps were developed for work and educational trips which are shown and discussed in following subsection.

5.2 Work Trips

FIGURE 45 shows the map of utilizing Motorbike for work trips. The values are obtained with respect to car (which is reference and has 0 value). It can be now be spotted that Town 1, 4 & 11 have highest utility for bike. Their geographical position, being closer to many industrial area (such as Town2, 10 and 11), allows them to use bike for reaching their destinations within desired duration. Unlike to them, those living in the center of the city majorly perceive bike as disutility as compared to car. Firstly, the prolonged travel time along with the availability of car makes car journey more relaxed than bike. Moreover, as mentioned in FIGURE 22 before, the utility for bike in work trips tends to decrease for travel time above 35 minutes (irrespective of town).

FIGURE 46 shows the utility associated to van as of car. The most important town for van in Bin Qasim Town (Town 17). As mentioned earlier, during the Value of Time estimation of National Highway, Bin Qasim Town in the industrial area behind National Highway. The industrial area is not properly connected with buses and due to heavy traffic congestion it is mostly avoided by motorbike. Therefore, vans are majorly preferred by employees working here. Similar to this, people living here also prefer van as it take longer time to reach other industrial areas which are located far away from this location. Alongside with Bin Qasim Town is the Korangi Industrial Area (Town 10) and therefore it also favors van over car (for shorter commute time).

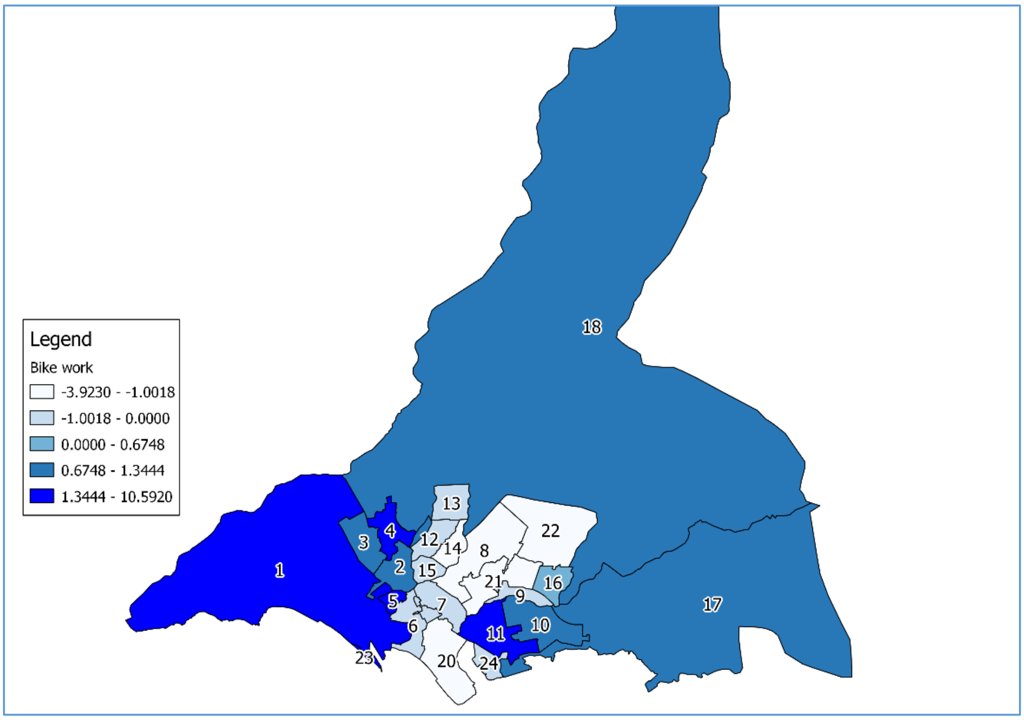

FIGURE 45 GIS Map of utilizing Motorbike/Car for Work trips.

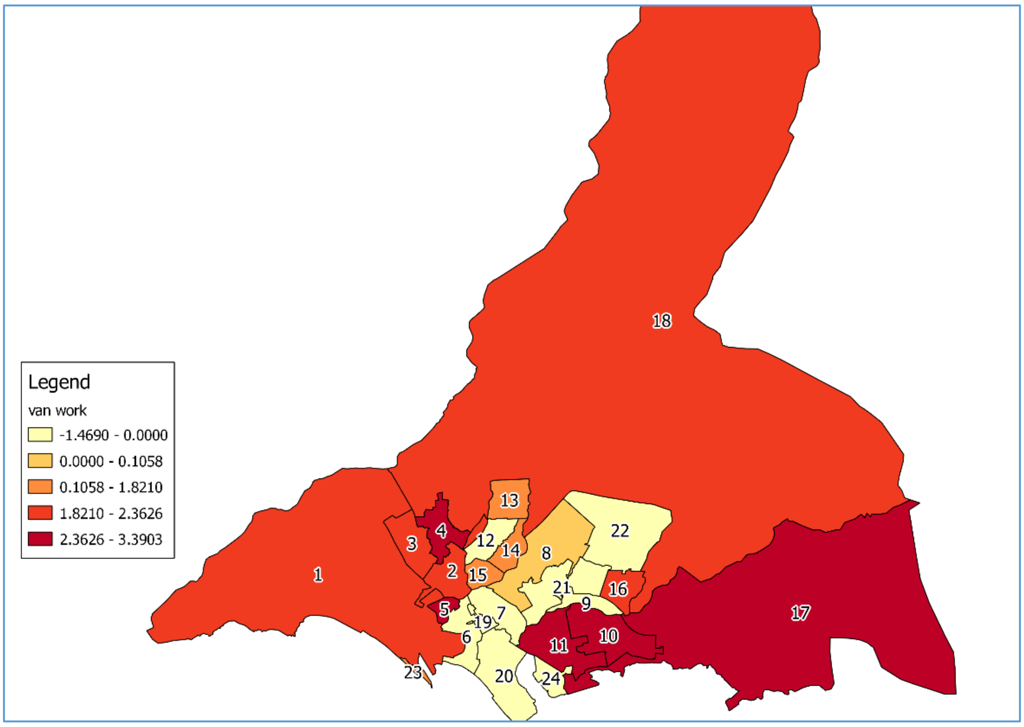

FIGURE 46 GIS Map of utilizing Van/Car for Work trips.

Similar trend as in case of bike is found in van as well where car remains to be more comfortable in town Central Towns. Analogous trends, as of bike and van, were found for Taxi and Public Bus as well are therefore shown in Appendix D.

5.3 Educational trips

Previous analysis revealed Taxi with highest utility for educational trips. FIGURE 47 shows the regions which utilizes Taxi for work trips. It is evident that majority of Towns consider Taxi more beneficial for educational trips, which was not the case in work trips. Only people from small number of Towns (represented with white and light blue in map) find their private Car more feasible for educational trips. This has perhaps a strong concern with their social status and reputation associated with car.

FIGURE 48 shows the usage of bike over car for educational trips. In comparison to its utility for Work trips (FIGURE 45), motorbike is found to be less valuable. This points to major perceptions. First, although bike ownership is very common (available on small monthly payments), it is not common for educational trips (undertaken by students).

5.4 Preference of Car over other transport mode

FIGURE 49 and FIGURE 51 shows the map between Car and Taxi and Car and Bike for work trips. It is evident that Towns which are located near City center and distant from major industrial areas, car remains of high importance than other transport modes. In addition, these Towns can be classified as more privileged in terms of status, therefore car ownership also plays an important role in its rank over other transport modes.

Van is slightly more preferred car as compared to Taxi. Since Van is more cost efficient than taxi and is solely run by companies for their employees (sometimes covering travel cost as well) it is utilized by many employees

Similarly, FIGURE 50 shows the relation between car and Taxi for educational trips. As compared to work trips, Taxi is more common for educational trips. Taxi provides an option to divide the share among all passengers alongside its comfort and reliability it is hugely preferred for educational trips.

For educational trips bike remains more feasible than private car. This can be seen in by comparing FIGURE 51 and FIGURE 52 where only a fewer towns who value car for work trips continue to value it more than bike for educational trips as well.

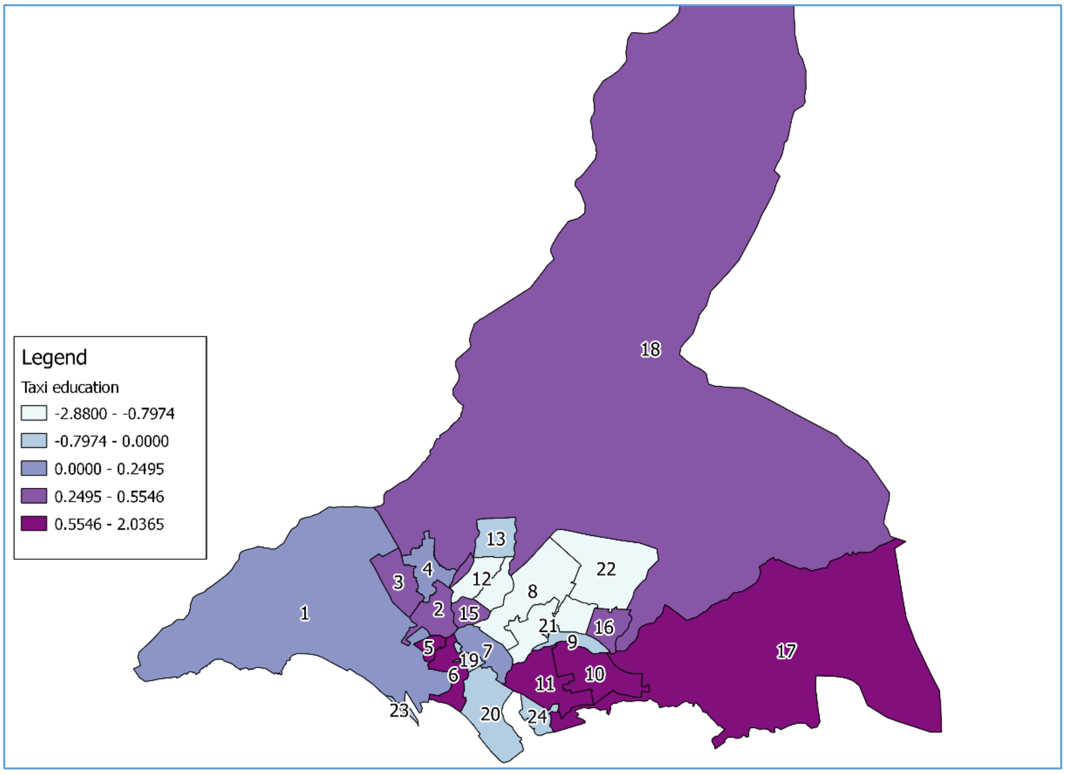

FIGURE 47 GIS Map of utilizing Taxi/Car for Educational trips.

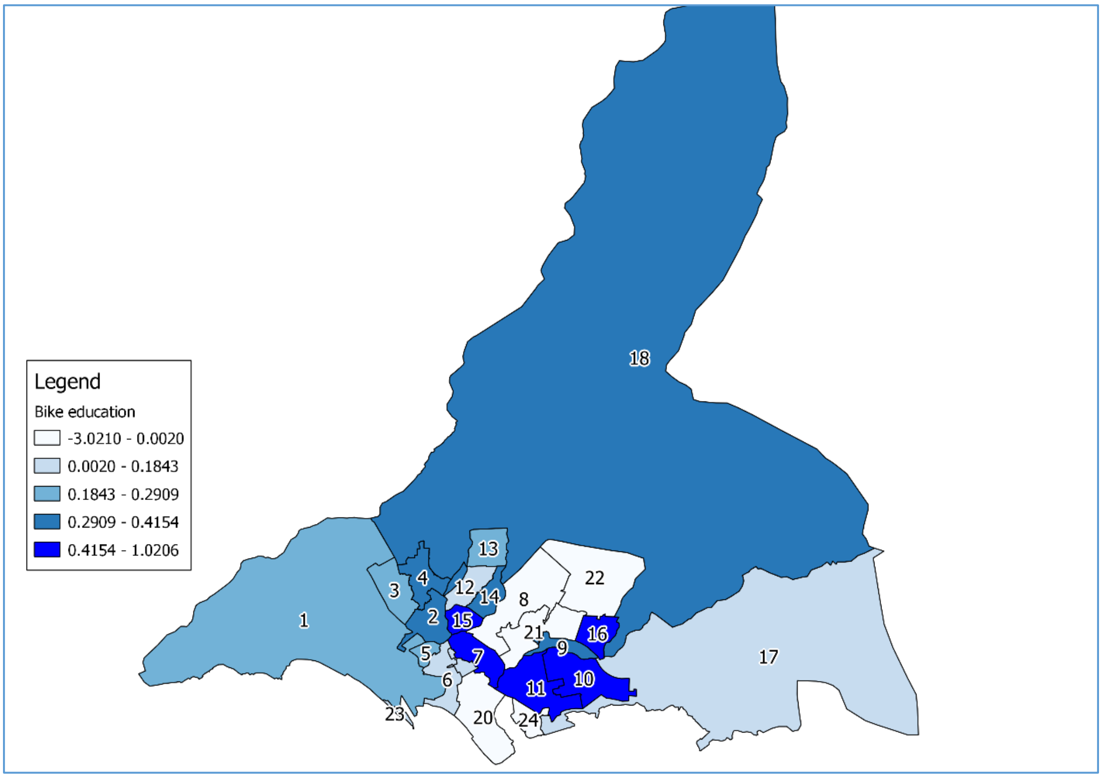

FIGURE 48 GIS Map of utilizing Motorbike/Car for Educational trips.

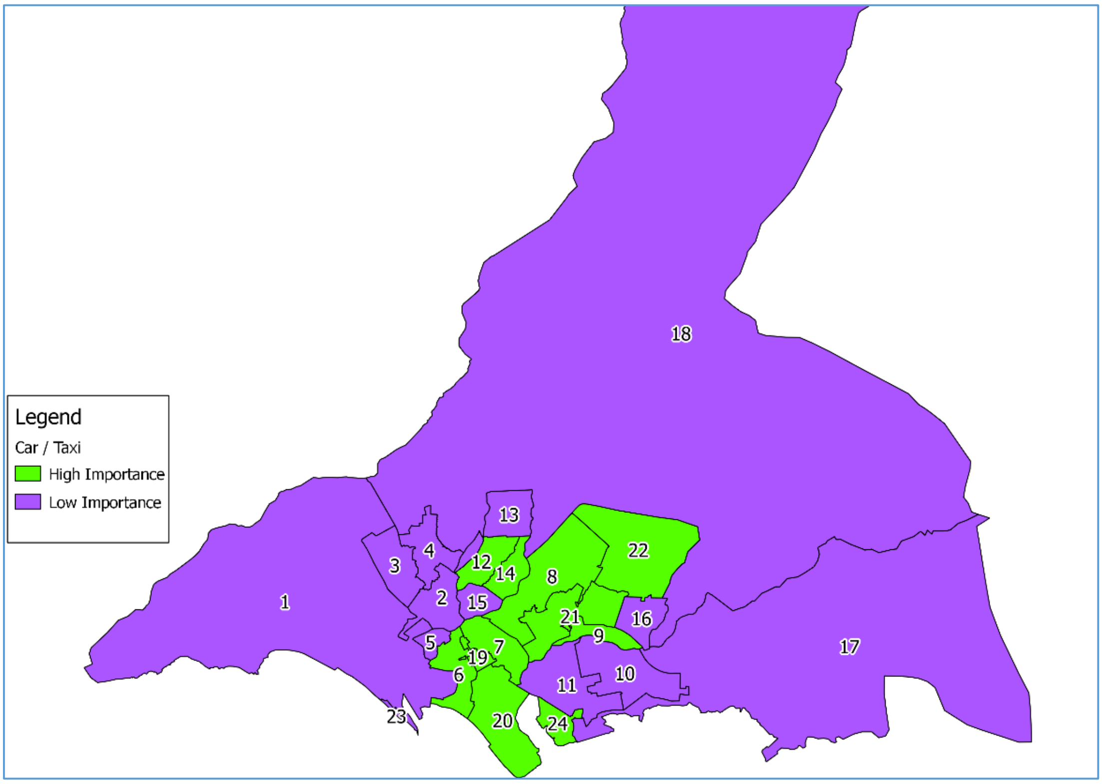

FIGURE 49 GIS Map of Car Relevance over Taxi for Work trips.

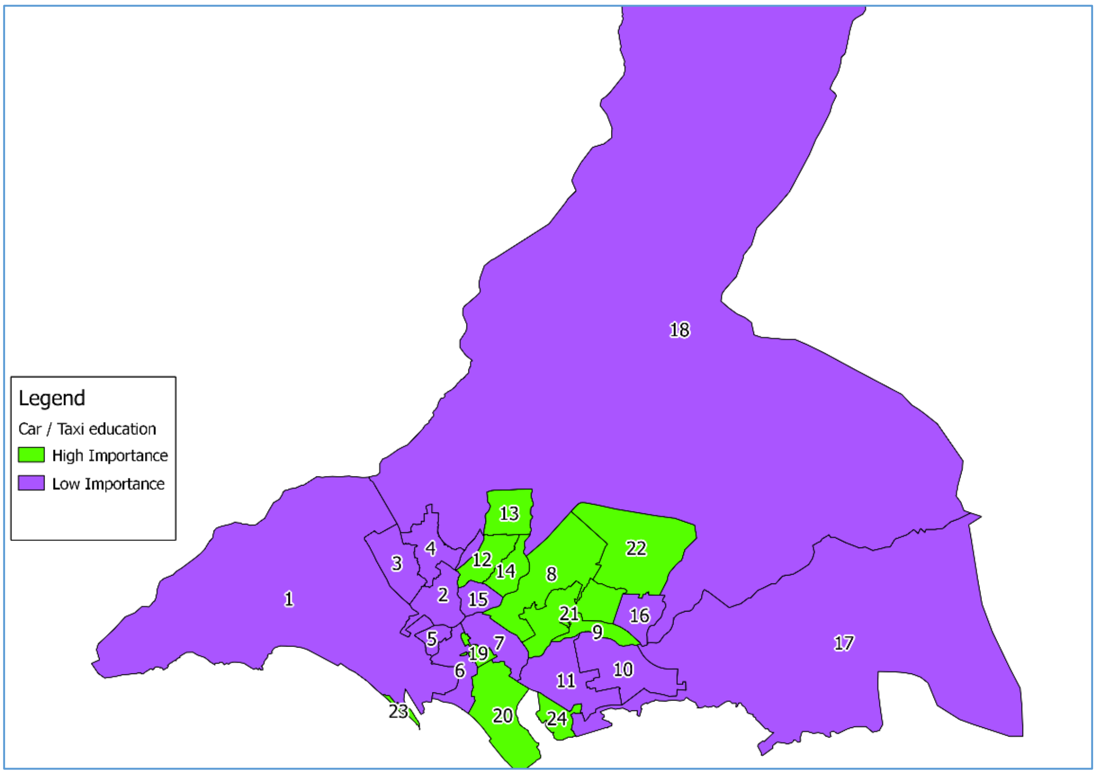

FIGURE 50 GIS Map of Car Relevance over Taxi for Educational trips.

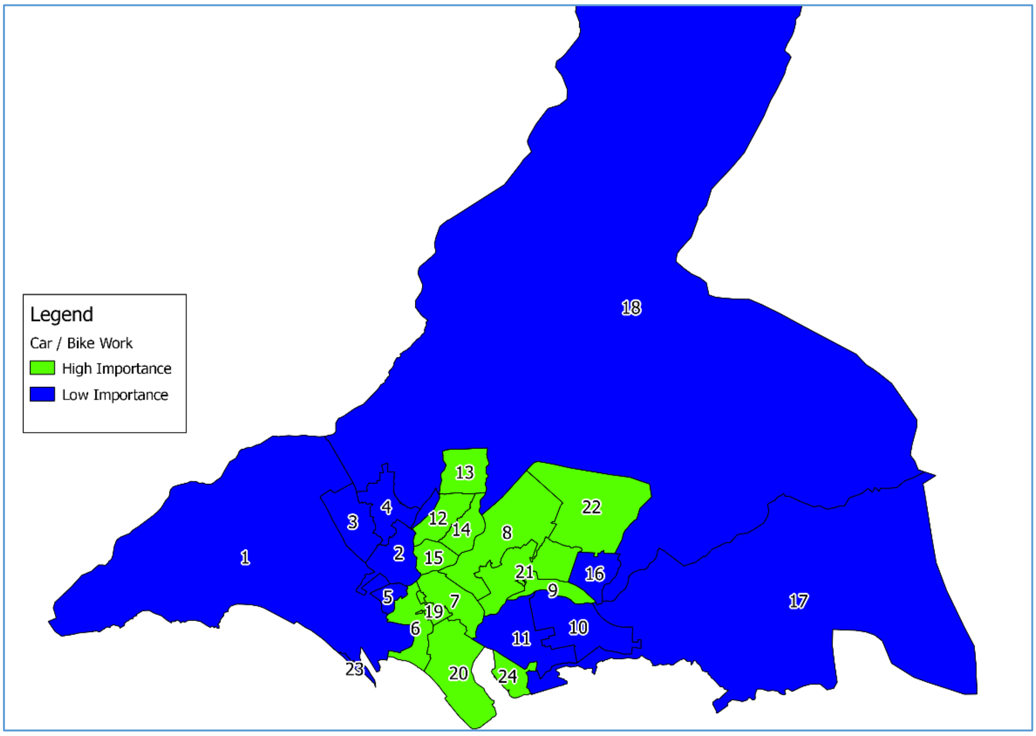

FIGURE 51 GIS Map of Car Relevance over Bike for Work trips.

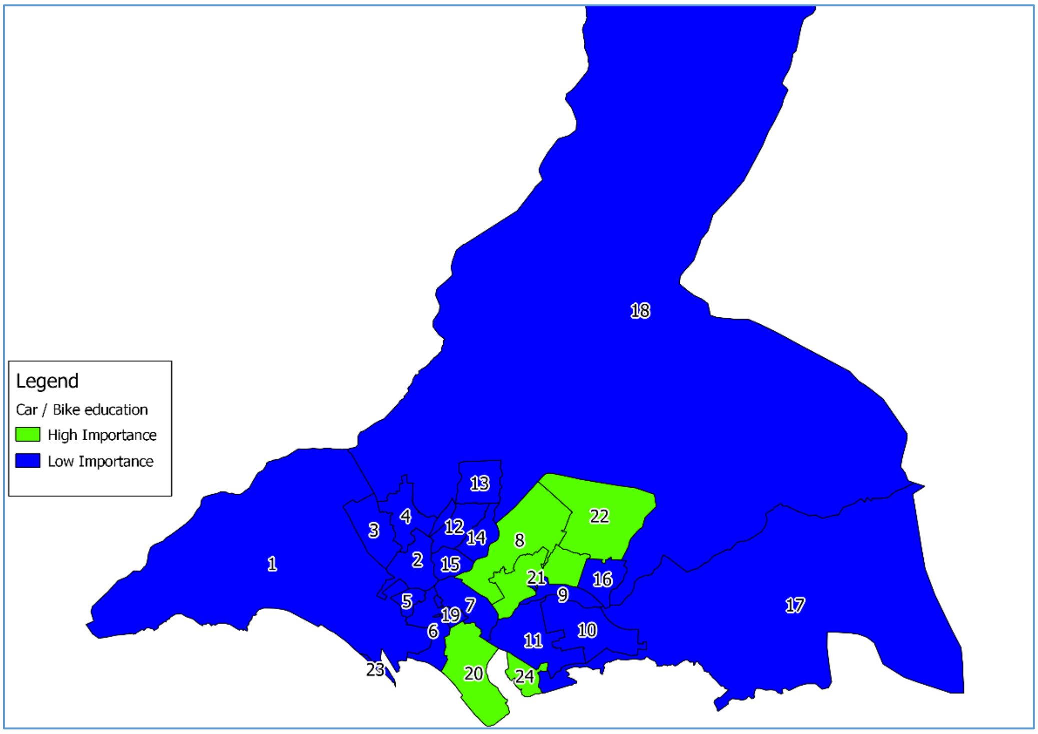

FIGURE 52 GIS Map of Car Relevance over Bike for Educational trips.

Chapter 6: Questionnaire Survey

6.1 General

This section describes the questionnaire survey developed to capture the travel attributes of commuters living in Karachi. The focus of this survey was to:

1. Collect information of socioeconomic attributes.
2. Collect statistics of travel affinity and disliking.
3. Design the Stated Preference questionnaire to capture VOT.

With these targets, the questionnaire survey was divided into three major parts; each corresponding to a specific target.

6.2 Part 1: Socioeconomic Information

At the start of the survey personal information was collected such as Age, gender, Town, and Employment status. These are usually collected at the start of a survey and used in in-depth analysis such as analyzing the trend with respect to gender and age group.

Income group was purposefully discarded from the survey, due to the vulnerability of the respondent's data. In addition to it, the survey was developed on Qualtrics software and distributed through 'online platform' social email and social media. Therefore it was important to avoid income information. However, keeping in view the importance of income in Valuing travel time; respondents were asked to enter average travel cost per month. This to some extent replaces the constraints associated with income and further reinforce the data to investigate the impact of Travel budget (if any).

6.3 Part 2: General Travel Attributes

In the second part of questionnaire details of travel mode, traveling frequency and travel expenses were asked. Additionally, the respondents were also asked to comment if they like their time spent on travelling. Based on the answer about employment status (asked earlier) the respondents were asked predefined questions.

For instance, employed people were asked to answer keeping in mind their work trips, whereas students were asked to provide an answer based on their educational trip. This is further explained below.

Keeping in the view the process of data collection and the possible biasness associated with it; the respondents were only separated into three categories (employed, unemployed and students) but the choices available to them remained same.

6.4 Part 3: State Preference

In correspondence with the second phase, the stated preference survey was also organized according to employment status. The respondents were asked to keep in mind their trip to workplace or educational institute respectively. Each of the respondents were given 5 similar questions each having 2 choice set to choose from.

The next and last part of the survey consisted of SP questions for shopping trips. These questions were asked to each respondent irrespective of their employment status. The arrangement was similar to with SP questions asked earlier.

6.5 Stated Preference Questionnaire Design

The design of SP questionnaire was the most important part of questionnaire survey. It consisted of selecting the parameters that are considered important in estimating VOT and later setting their values/levels. In total five parameters were selected based on their association in undertaking a trip and significance present in literature. These parameters were travel time, travel cost, congestion, safety and walking speed.

Based on the possibility of lexographic reactions as explored by Kaa; the parameters were arranged in the same order as below:

1. Travel time
2. Travel Cost
3. Congestion
4. Safety
5. Walking speed

These parameters were placed at the same position for each question as otherwise it adds to the complexity of the task for respondents.

Online data collection has its own advantages as well as constraints. The biggest advantage associated with online surveys is cost effectiveness. Availability of various online software such as Qualtrics (also used in this survey) makes survey preparation, distribution and collection absolutely free. In comparison to it, door-to-door surveys can be costly. However online surveys also have their limitations. For instance accessibility; only persons who are 'aware of' such survey such as through a social media campaign have a chance to answer it (conditional on their temperament). While, in case of door-to-door survey any household can be randomly selected for data collection. Specifically in context of our study area Karachi, not all population have access to internet therefore biasness is always possible. For example we were unable to collect the data from all towns (also mentioned in analysis below).

Keeping in view the above stated constraints of online survey (lower response rate than in person survey) or respondents (higher response rate for students than employed people or vice versa); 0.25 or 25% fractional factorial design (explained later) was selected with 5 attributes and two level each. The design was generated through SAS software. By this, each respondent (for a specific scenario) has to answer same questions with same attributes level.

6.5.1 Defining Alternatives

The most important part of designing an experimental design is the identification of alternative and their levels. Although, when referring to mode choice, the alternatives are finite but defining a universal set that fits all respondents is a tough task. Sometimes it is possible that some alternatives are available to some population and not all (for instance, van in not a travel option for employees of every company). In such cases defining alternatives is certainly tough.

6.5.2 Attributes and Attributes Levels

Once alternatives are decided the next step is to define their attributes. First we need to identify the attributes which are common to each alternatives (already selected). For instance, in case of public transport the common attributes can be frequency, headway, seating capacity and waiting time. However, in case of private vehicle (car and motorbike) none of these attributes are common.

When talking about attribute levels, the decision maker has to communicate the meaning associated with the level of each attribute. For instance, in case of comfort in public transport some respondent may consider bus temperature and softness of seats as criteria for judgement while other may only consider passengers onboard that effect personal space as a measure of comfort.

To minimize this impact the levels should be converted to number where possible. For instance travel time and cost should not be presented as low, high medium but in number (such as 10min, 20min and 20Rs, 50Rs) respectively.

All these stated points were taken into special attention while designing the questionnaire survey. The level of each parameter was also placed close to each other otherwise the results are fabricated to be high than actual value (O'Fallon, January 2012). Defining attributes in two level and that too close to each other (especially in case of travel time and cost) was a difficult assignment. However, the values were placed such that they remain realistic regardless of travel mode. With this understanding, the following values, as shown in Table 12, of travel time and travel cost were assigned for each trip purpose.

TABLE 12 Parameters' Level and assigned values for Travel Time and Travel Cost.

Purpose	Travel time (min)		Travel Cost (Rs)	
	High	Low	High	Low
Work	70	60	100	80
Education	50	40	55	45
Shopping	40	30	50	40

6.5.3 Full factorial and fractional factorial design

A full factorial design is such a design in which all possible treatment combination are shown. The number of treatment combinations can be calculated by the formulae:

$$treatment\ Combinations = Number\ of\ Levels^{Number\ of\ Attributes} \tag{11}$$

If there are 2 attributes with three levels each then the total possible number of combinations for a full factorial design would be nine (3^2 =9). Similarly in this case total 5 attributes were selected with 2 level each, so in order to create a full factorial design each respondent has to answer 32 datasets (2^5=32).

Thus it was practically impossible to make each respondent answer 32 choice questions; besides other general questions. Therefore instead of full factorial design a fractional factorial design was selected.

A fractional factorial design is such as design in which not all combinations are tested but only a subset of them. In this case 25% (or 1/4) of all possible combinations were tested. Perhaps the matter of interest lies in the selection of those treatments which are to be tested. For this purpose, program was run on SAS software to identify the treatments and arrange them in their choice set such that maximum possible interaction in covered.

Although, full factorial design are most rich in providing information about effects of each parameter, fractional factorial designs are most commonly used due to easiness during data collection.

Another prospect to use a full factorial design is the breakdown of all treatments into blocks. For instance, instead of 32 choice questions each of the respondent has to answer 8 questions. The answers of 3 different respondents combined form one complete survey. These blocks are generally provided to each respondent based on a random question such as month of the year you are born, are you left handed or right handed.

Although this approach is widely used in data collection, chances are that due to small response rate some blocks may be excessively answered and vice versa.

6.6 Questions filtering

In order to distinguish among the answers three different employment categories were formed. This included:

1. Employed
2. Unemployed
3. student

Based on the answers provided the respondents were asked to answer the questions. Employed people were inquired about their trip to work place. Students were asked to provide details of their educational trip while unemployed people (only 2 responses) were asked general trip details.

6.7 Data collection

The survey was designed on Qualtrics which is an online platform. It is specially designed to design and spread online questionnaire surveys. Since the study area was Karachi, the online platform was most feasible to spread and collect the survey in a short time period.

The link to the questionnaire survey was spread on social media and also emailed to other contact persons who helped in spreading the survey and arranging responses in a short time period. I am very grateful to them for their cooperation.

Complete questionnaire survey is shown in appendix E.

6.8 Analysis

6.8.1 General

Although the response rate for the survey was low (52 total responses) the survey provided some nice insights of the travel behaviour. Among these only 2 responses were from unemployed persons. Therefore, the analysis was kept limited to employed persons and students.

This section explains the results of the general questions. Figure 53 below shows the travel time enjoyment for work trips. In total 50% of the respondents rated that they agree or strongly agree with this statement. However, 21% neither like nor dislike their travel time.

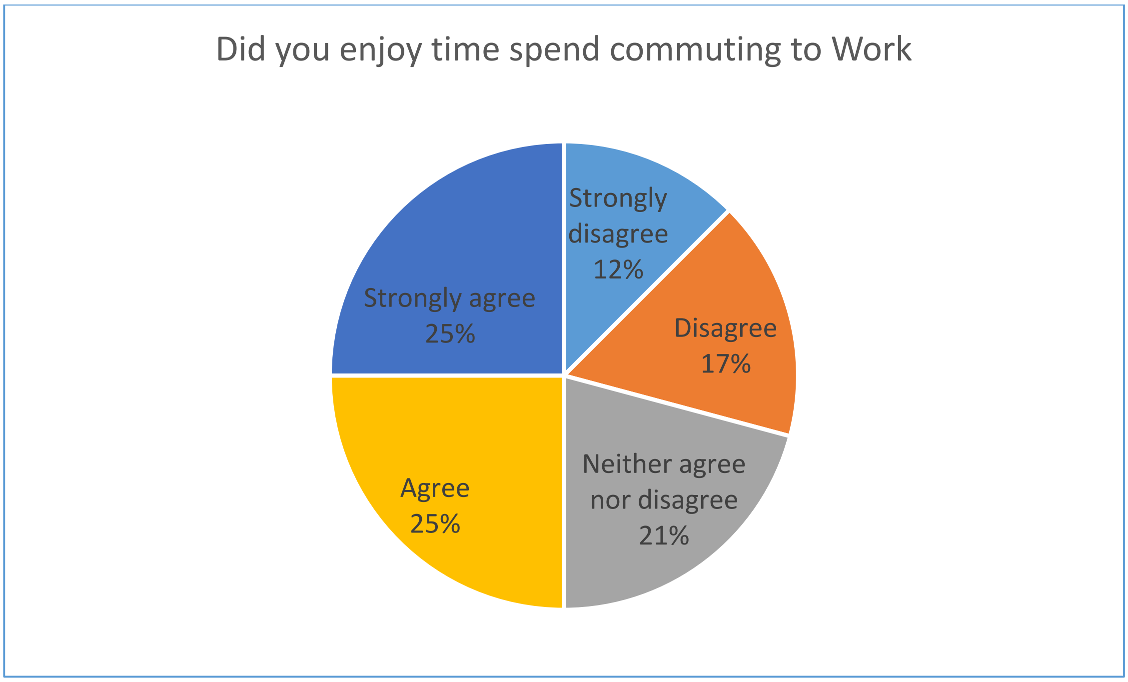

FIGURE 53 Commute time enjoyment for Work Trips.

Figure 54 shows how the time is spent for educational trips. Only 16% stated against this statement. Therefore, it can be safety stated that most of the students enjoy their time spent in educational trips. This is mainly because educational trips are conducted with friends.

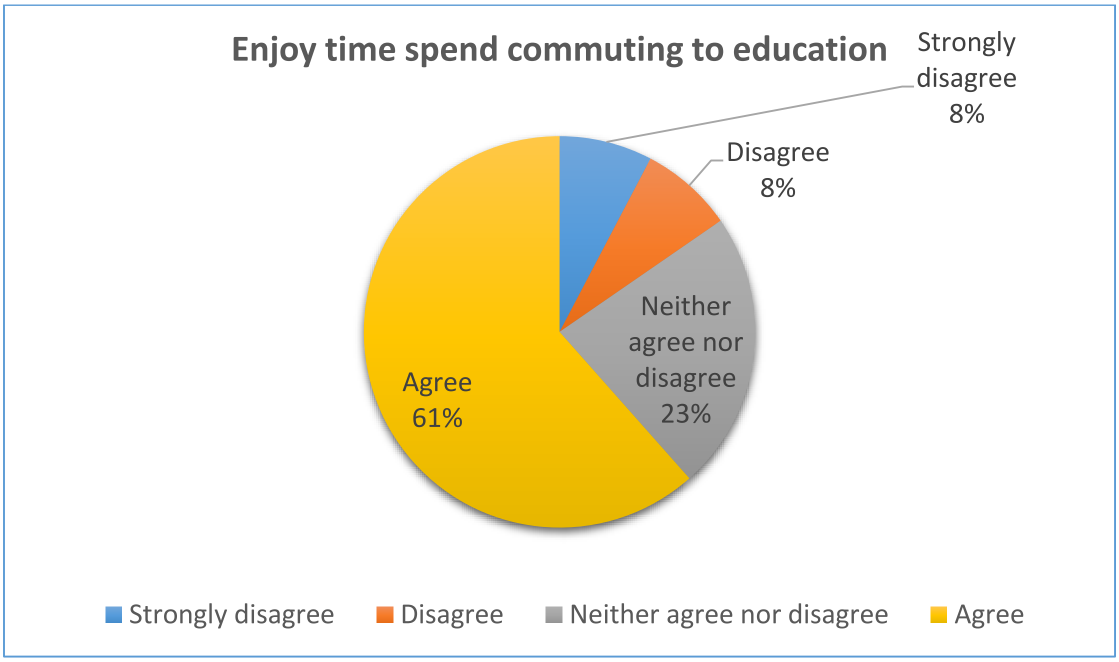

FIGURE 54 Commute time enjoyment for Education Trips.

For employed person, only 33% were satisfied or extremely satisfied with their travel time while 29% were extremely dissatisfied. While, for educational trips 58% reported neither satisfied nor dissatisfied. Perhaps, travel time was not of much importance as most of them appear to enjoy it. These graphs are shown in Figure 55 and Figure 56 respectively.

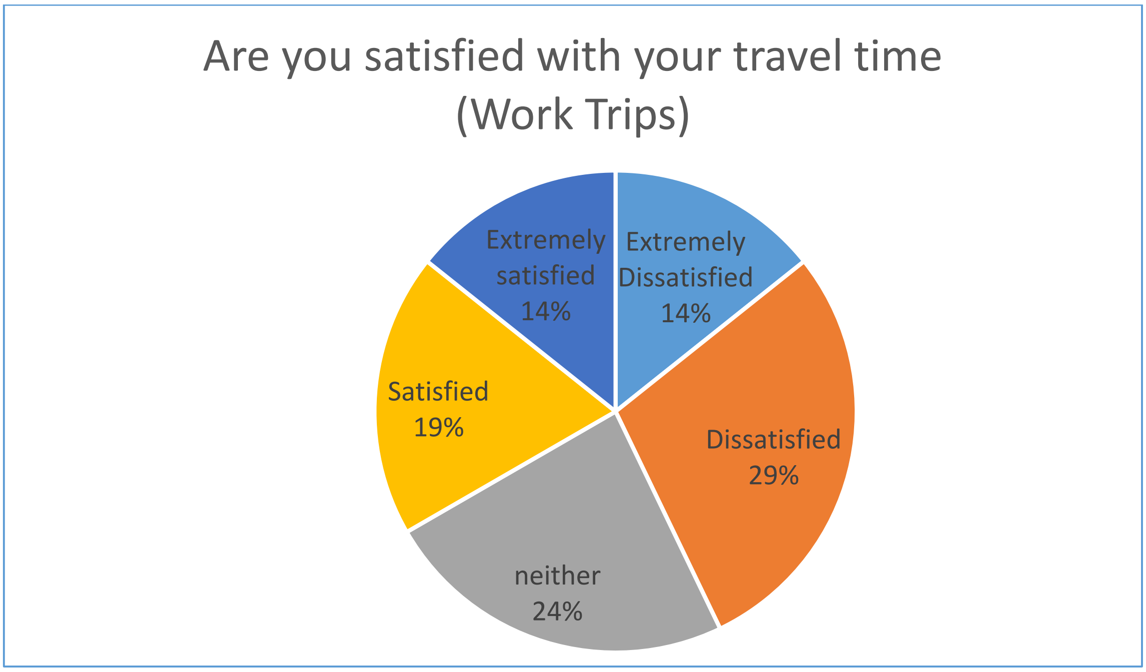

FIGURE 55 Travel Time Satisfaction for Work Trips.

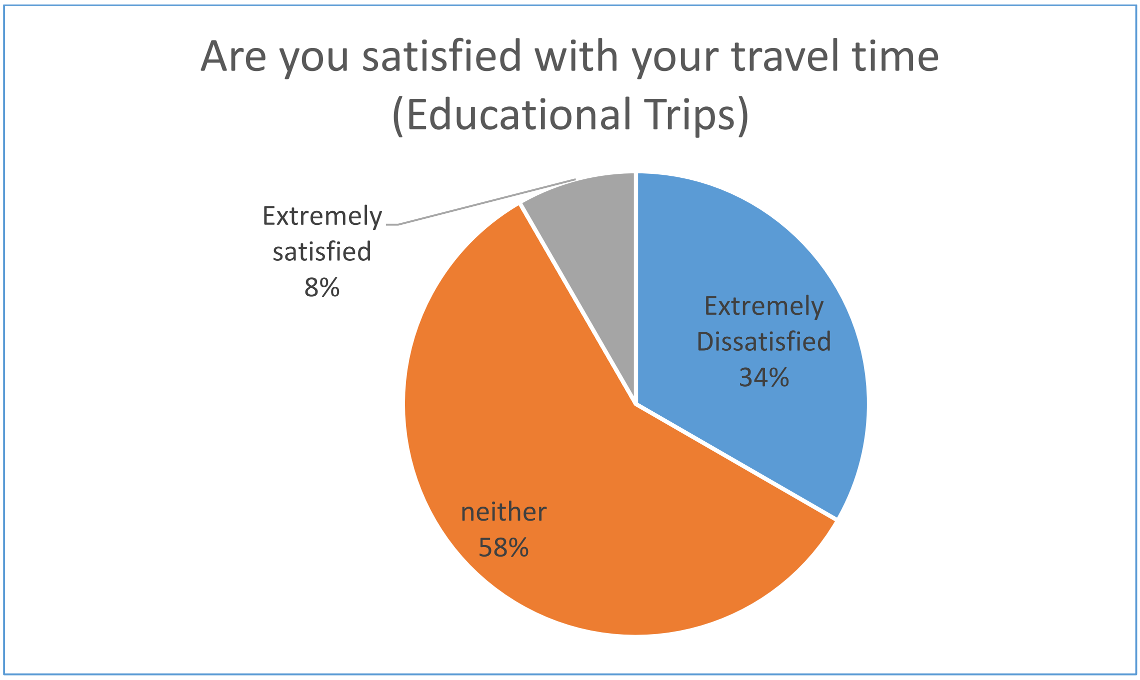

FIGURE 56 Travel Time Satisfaction for Educational Trips.

6.8.2 Comparison of Questionnaire and HIS Survey Results

The questionnaire survey provided a good base to compare the results previously obtained from the analysis of HIS survey. Even though the response rate was low but the comparison provided some nice insights. Figure 57 below shows the GIS image of average mode preference for work trips. Car preference remains higher in the same towns as it was in previous analysis (refer to FIGURE 51). However, the result of Town 13 does vary from previous result.

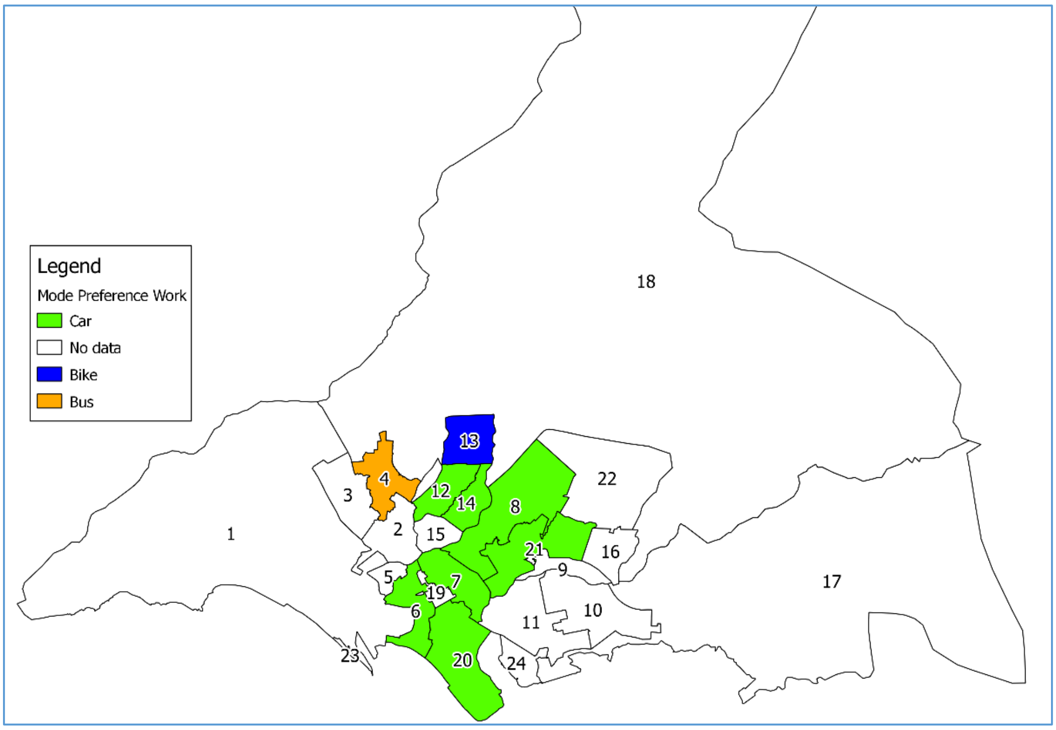

FIGURE 57 Questionnaire Survey Results for Work Trips.

Similar analysis was also conducted for educational trip as shown in Figure 58 however the results were quite dissimilar; perhaps due to the small dataset (N=10).

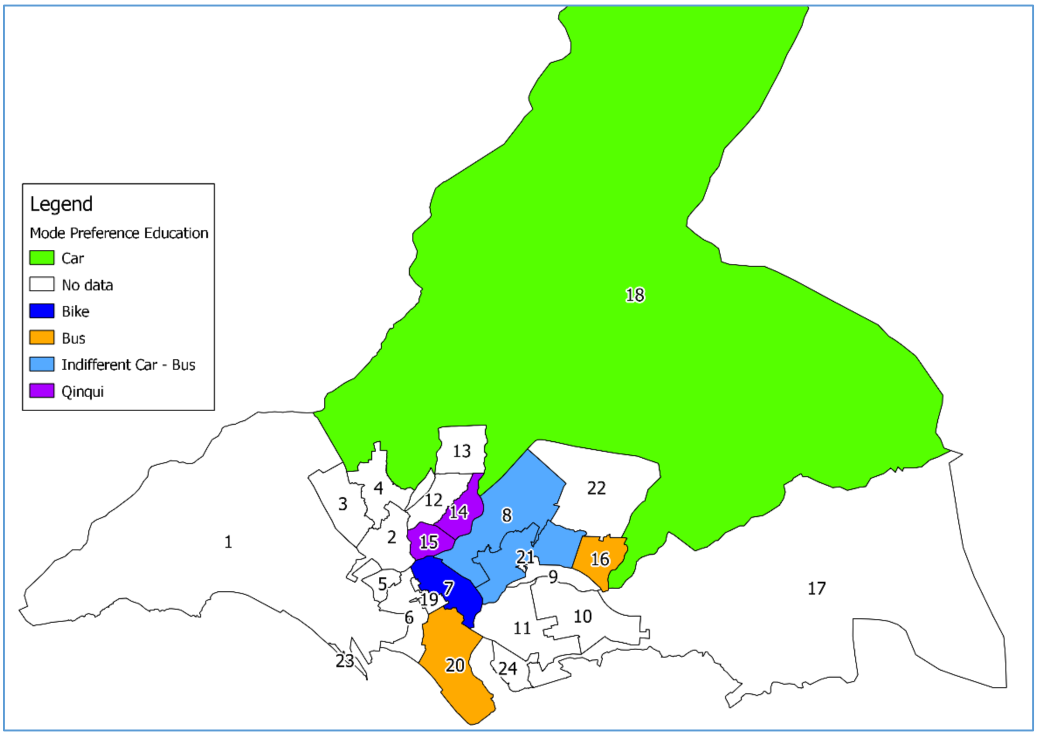

FIGURE 58 Questionnaire Survey Results for Educational Trips.

Chapter 7: Conclusion and recommendations

7.1 Conclusion

The objective of this study was to estimate Value of Time for diverse regions. For this purpose Karachi metropolitan was selected as study area. The scope of this study was to incorporate the unequal attributes of residents. The city comprises of posh localities to some slum area thus making travel demand modelling a challenging task.

Therefore, the first objective of this study was set to analyze the impact of traffic congestion on Value of time. There were numerous studies undertaken in the past and are mentioned in the references that investigated this effect as a fraction of journey. However, the novelty of this study was complete traffic congestion. The results were proved to be in strong association with that stated in previous studies. In addition to it, intermodal VOT was also estimated which revealed enormous difference in VTTS in car and other transport modes.

Based on the work done in this study a research paper on "Estimation of Value of Time for a Congested Network – A case study of the National Highway, Karachi" written by the same author as this thesis was accepted for presentation at Urban Transport 2015 conference, Wessex, Spain. This paper is also attached in appendix F.

This being said, the next step of this research was to determine the 'importance of travel time' associated with each mode. Traffic in Karachi city is heterogeneous to a very high degree. It includes form non-motorized transport to motorbike, private car, van, taxi, three wheeler and Qinqui; most of which are common in the sub-continent.

Contrary to VOT estimation in traffic congestion where the study area was specific Port Qasim industrial area, this study was focused to analyze the associated Value of Time for residents of entire Karachi city. Keeping in view the diverse socioeconomic setting the study was conducted at Town level. Karachi city of consists of 24 Towns (18 towns + 6 Cantonment areas). Household Study Data was used for analysis (JICA, 2010). Mode choice models were developed and analyzed through Logit Models in SAS software.

The upshots revealed a strong impact of travel mode, activity purpose and Town (as a socioeconomic characteristic) on valuing travel time. Further on, GIS maps demonstrated valuable information on valuing travel time relating to geographic location. It is comprehended that people living close to city center and residential area value car more than any other transport mode. However, those who live in suburbs, value economic travel mode.

7.2 Future work

This study opens the door for future work that can be performed to further analyze the travel behavior in more depth.

Future studies should also perform the analysis with respect to time of day. It was reported in many studies that transport mode choice and its associated value is closely related to time of the day when the trip is undertaken. This will also assist in developing the relation of transport choice with respect to time pressure.

Keeping in view the time constraint, only work (including business) and educational trips were analyzed. The data also contains a detailed information for other trips purposes. This work should be extended for all other purpose to ensure a rich picture. It is also expected that shopping and eating trips will provide quite attention-grabbing and unlike results as obtained in this study.

GIS maps can be used for more detailed analysis by taking into account social factors of the commuters. Furthermore these maps were based on household location only. Similar maps can also be created using trip destination details and both the results can be compared.

Although the study was conducted at Town level (as many other transport related studies in Karachi). A more detailed assessment can be done at UC level similar to socioeconomic zoning (Mir Shabbar Ali, 2012). Moreover, the incorporation of a travel budget can be lead to ascertain VOT along with cut-off points for mode choice.

As different maps have been created based on the travel mode. It is highly recommended that these maps be merged into one single map showing multicultural Towns representing mode preference hubs.

This study have incorporated travel time as the main parameter keeping in view its significance. Some other parameters such as income level, travel budget, education level can be incorporated by assigning different weights to each of them. Furthermore, the presence of travel cost can also assist in estimating activity based VOT at town level.

Based on the mode choice models developed in this study, utility of transport modes can be valued against average travel time with respect to activity. This can produce fascinating insight to questions like: “does car have more utility than van for work trips longer than 30 minutes?” Hence it can prove to the first step towards activity based modelling in Karachi City.

Based on the online survey, the mode relevance analysis was limited to town level. However, upon availability of larger dataset the relation of mode preference can be better examined with variation in travel time.

This analysis was restricted to only trip based models. Tour based modelling can be more valuable for such work as it incorporates complete tour undertaken and not just a single trip.

References

1. Amer, K. (2013). Population explosion: Put an embargo on industrialisation in Karachi. *The Express tribune*.
2. Anable, J. a. (2005). All work and no play? The positive utility of travel for work compared to leisure journeys. *Transportation Research Part A: Policy and Practice, Volume 39*, p. 163-181.
3. Becker, G. (1965). A theory of the allocation of time. *The Economic Journal*, 493-517.
4. Belenky, P. (2011). *Revised Departmental Guidance on Valuation of Travel.* Washington: US Department of Transportation.
5. Belenky, P. (2011). *The Value of Travel Time Savings: Departmental Guidance for Conducting Economic Evaluations.*
6. Camille Kamga, M. A. (2014). Temporal and weather related variation patterns of urban travel time: Considerations and caveats for value of travel time, value of variability, and mode choice studies. *Transportation Research Part C*, 4-16.
7. Carlo Fezzi, I. J. (2013). Using revealed preferences to estimate the Value of Travel Time to recreation sites. *Journal of Environmental Economics and Management*, 58-70.
8. Carlos Carrion, D. L. (2012). Value of travel time reliability: A review of current evidence. *Transportation Research Part A*, 720-741.
9. CHEN Xumei, L. Q. (2011). Estimation of Travel Time Values for Urban Public. *JOURNAL OF TRANSPORTATION SYSTEMS ENGINEERING AND INFORMATION TECHNOLOGY*, 77-84.
10. Cirillo, C. a. (2004). Evidence on the distribution of values of travel time savings from a six-week diary. *Working Papers Transport and Spatial Planning 212 IVT. Zürich: ETH Zürich.*
11. David A Hensher, W. H. (2005). *Applied Choice Analysis: A Primer.*
12. de Borger, B. a. (2006). Another test of the theory of reference-dependent preferences: the trade-off between money and time. *Proceedings of the European Transport Conference.* Strasbourg, France.
13. De Serpa, A. (1971). A theory of the economics of time. *The Economic Journal* , 828-846.
14. Dijst, M. a. (2000). Travel time ratio: the key factor for spatial reach. *Transportation 27, no. 2*, 177-199.
15. Ettema, D. a. (2010). Multi-tasking and value of travel time savings. *TRR Journal of the Transportation Research Board*, 19–25.
16. Fangshu Lei, Y. W. (2014). A travel time reliability model of urban expressways with varying levels of service. *Transportation Research Part C*, 453-467.

17. Farhad Ahmed, K. G. (2004). THE VALUATION OF TRAVEL TIME SAVINGS IN LEAST DEVELOPED. *World Conference on Transport Research.* Istanbul.

18. Farhad Ahmed, K. G. (2004). THE VALUATION OF TRAVEL TIME SAVINGS IN LEAST DEVELOPED COUNTRIES: THEORETICAL AND EMPIRICAL CHALLENGES AND RESULTS FROM A FIELD STUDY. *World Conference on Transport Research.*

19. Fickling, R. H. (2008). The productive use of use rail travel time and value of travel time saving for travellers in the course of work. *Proceedings from the.* Leeuwenhorst Conference Centre, The Netherlands.

20. Flügel, S. (2014). Accounting for user type and mode effects on the value of travel time. *Research in Transportation Economics*, 1-11.

21. Fosgerau M., H. K.-J. (2006). An Integrated approach to the estimatino of the value of travel time. *Association for European Transport and Contributors*.

22. Gwilliam, K. M. (1997). The Value of Time In Economic Evaluation of Transport Projects; Lessons from Recent Research. The World Bank.

23. Iragüen, P. &. (2004). Willingness-to-pay for reducing fatal accident risk in urban areas: An internet-based web page stated preference survey. *Accident Analysis and Prevention, 36*, 513-524.

24. Jara-Diaz. (2003). On the goods-activities technical relations in the time allocation theory. *Transportation*, 245-260.

25. JICA. (2010). *'Karachi Transportation Improvement Project (KTIP) - 2030.* Karachi: Japan International Cooperation Agency.

26. Juan de Dios Ortuzar, L. G. (2011). *Transport Modelling.* John Wiley & Sons.

27. Kaa, E. J. (n.d.). Answering, Assessment Of The Value Of Travel Time From Stated Choice Surveys: The Impact Of Lexicographic Answering. *TRAIL Research School, The Netherlands.*

28. Kaa, E. J. (n.d.). ASSESSMENT OF THE VALUE OF TRAVEL TIME FROM STATED CHOICE SURVEYS: THE IMPACT OF LEXICOGRAPHIC ANSWERING. TRAIL Research School, The Netherlands.

29. Kahneman, D. &. (1979). Prospect theory: An analysis of decision under risk. (pp. 263-291). Econometrica, 47.

30. Kay W Axhausen, A. K. (n.d.). SWISS VALUE OF TRAVEL TIME SAVINGS. *Institute of Transport Planning and Systems (IVT).*

31. Khan, O. (2007). *Modelling passenger mode choice behaviour using computer aided stated preference data.* School of Urban Development, Queensland University of Technology.

32. Lioukas, S. K. (1982). Choice of Travel Mode and Value of Time in Greece. *Journal of Transport Economics and Policy*, 161-180.

33. Louviere, J. J. (2000). Stated choice methods: analysis. *Cambridge, UK: University Press.*

34. Lyons, G. a. (2005). Travel time use in the information age. *Transportation Research Part A: Policy and Practice 39, no.2–3*, 257–276.

35. Mackie, P. W. (n.d.). Values of Travel Time Savings UK. *Institute of Transport Studies,University of Leeds, .* Working Paper 567.

36. Marshall, A. (1920). *Principles of Economics. An introductory volume (8th ed.).* London: Macmillan. Retrieved from http://en.wikipedia.org/wiki/Utility

37. Meilan Jiang, T. M. (2004). Theoretical analysis on the variation of value of travel time savings. *Transportation Research Part A*, 551-571.

38. Metz, D. (2003). Travel time constraints in transport policy. *London.* Population Ageing Associates.

39. Mir Shabbar Ali, M. A. (2012). Development of Socio-Economic Zoning System of Karachi for Effective Transportation Planning. *AWAM International Conference in Civil Engineering (AICCE'12) and Geohazard Information Zonation (GIZ'12).*

40. Mir Shabbar Ali, M. A. (2014). Estimation of Traffic Congestion Cost-A Case Study of a Major. *Fourth International Symposium on Infrastructure Engineering in Developing Countries, IEDC 2013* (pp. 37-44). Karachi: Procedia Engineering.

41. Mokhtarian P.L., S. I. (2001). How derived is the demand for travel? Some conceptual and measurement. *Transportation Research A 35 (8)*, 695-719.

42. Mokhtarian, P. L. (2005). Travel as a desired end, not just a means. *Guest editorial, special issue on the Positive Utility of Travel, Transportation Research A 39*, 93 - 96.

43. O'Fallon, C. (January 2012). *A wider look at how travellers value the quality and quantity of travel time .* Wellington: Pinnacle Research & Policy Ltd, Wellington Ian Wallis, Ian Wallis Associates Ltd.

44. Oort, O. (1969). The evaluation of traveling time. *Journal of Transport Economics and Policy* , 219-286.

45. Patricia L., M. I. (2001). Understanding the Demand for Travel: It's not purely 'Derived'. *Innovation*, 355-380.

46. Pedro A.L. Abrantes, M. R. (2010). Meta-analysis of UK values of travel time: An update. *Transportation Research Part A*, 1–17.

47. *Regression Using Excel's Solver*. (n.d.). Retrieved from http://archives.math.utk.edu/ICTCM/VOL13/C013/paper.html

48. Research, C. f. (Accessed November 2010). Travel time use in the information age: report. Prepared for Engineering and Physical Sciences Research Council. www.transport.uwe.ac.uk/research/projects/travel-time-use.asp.

49. Richardson, A. (2003). Some evidence of travellers with zero value of time. *82nd Annual Meeting of the Transportation Research Board.* Washington, DC.

50. Rizzi, L. I. (2003). Stated preference in the valuation of interurban road safety. *Accident Analysis and Prevention, 35*, 9-22.

51. Saelensminde, K. (2001). Inconsistent choices in stated choice data. Use of the logit scaling approach to handle resulting variance increases. *Transportation, 28*, 269-296.

52. Shen, Q. (1998). Location characteristics of inner-city neighborhoods and employment accessibility of low-wage workers. *Environment and Planning B: Planning and Design*, 345-365.

53. Smalkoski, B. R. (2003). VALUE OF TIME FOR COMMERCIAL VEHICLE OPERATORS IN MINNESOTA. *Master thesis FACULTY OF THE GRADUATE SCHOOL; UNIVERSITY OF MINNESOTA.*

54. Small, K. (1982). Scheduling of consumer activities: work trips. *American Economic Review*, 467-479.

55. Steg, L. (2005). Car use: lust and must. Instrumental, symbolic and affective motives for car use. *Transportation Research Part A 39*, 147–162.

56. Susan Handy, L. W. (August 2003). Driving by Choice or Necessity? *10th International Conference on Travel Behaviour Research.* Lucerne.

57. Turcotte, M. (2006). Like commuting? Workers' perceptions of their daily commute. *Canadian Social Trends 82*, 35–41.

58. Vega, A. (2012). Using Place Rank to measure sustainable accessibility. *Journal of Transport Geography*, 411-418.

59. VPTI. (2013). *Transportation Cost and Benefit Analysis II – Travel Time Costs.* Victoria Transport Policy Institute.

60. Waldo, A. (1999). The underlying reasoning of travel behaviour. *Proceedings from Urban Transport Systems Conference.* Lund, Sweden.

61. Wardman, M. (2004). Public transport values of time. *Transport Policy*, 363-377.

62. William F. Mcfarland, M. C. (1985). the Value of Travel Time: New Elements Developed Using a Speed Choice Model. *Transportation Research Record*, 15-21.

63. Zaiontz, C. (n.d.). *Real Statistics Using Excel*. Retrieved from Finding Logistic Regression Coefficients using Excel's Solver: http://www.real-statistics.com/logistic-regression/finding-logistic-regression-coefficients-using-excels-solver/

Appendix A: QUESTIONNAIRE TRAFFIC CONGESTION

Date: __-__-2013 Time: ____:____ REF:

Survey place:

General

Name					
Age	Below 15	15-30	31-40	40-60	60 +
Gender	M		F		

Current/Last Trip

Origin:			Origin time:
Destination:			Journey Time:
Approximate Remaining Time:			Vehicle:
Purpose:			
Travelling as	Driver	Passenger	
Fuel used by vehicle :	Petrol	CNG	Diesel

Most Frequent Mode of Travelling

CAR	BIKE	BUS/QINQUI	SUZUKI	VAN	3-WHEELER	FOOT	OTHER

Daily expenses on travelling: _______________ No. of trips on daily basis:

Monthly expenses on travelling: ___________ Daily Km travelled:

Trip Time:

Average: ____min	Shortest: ____min	Longest: ____min

Most common reason(s) to you for the delay? (Tick appropriate)

1. Queue	
2. Congestion	
3. Signal not working completely/ inefficient	
4. Traffic incident	
5. Bottleneck	
6. Pavement distresses	
7. Illegal parking	

STATED PREFERENCE CHOICE

FOR **CAR** USERS

Bike ownership YES NO

PLAN A	PLAN B	PLAN C	PLAN D
BUS/QINQUI	BIKE	3-WHEELER	OFFICE VAN
Time = 20min more	Time = 10 min less	Time = Same	Time = 20min more
Cost = Rs. 50 less	Cost = Rs30 less	Cost = Rs. 30 more	Cost= Rs. 30 more

FOR **BUS/QINQUI** USERS

Car ownership YES NO
Bike ownership YES NO

PLAN A	PLAN B	PLAN C	PLAN D
CAR	BIKE	3-WHEELER	OFFICE VAN
Time = 20min less	Time = 20min less	Time = 20min less	Time = 10min less
Cost = Rs. 50 more	Cost = Rs. 30 more	Cost = Rs. 70 more	Cost= Rs. 50 more

FOR **BIKE** USERS

Car ownership YES NO
Bike ownership YES NO

PLAN A	PLAN B	PLAN C	PLAN D
BUS/QINQUI	CAR	3-WHEELER	OFFICE VAN
Time = 25min more	Time = 10min more	Time = 10min more	Time = 30min more
Cost = Rs. 20 less	Cost = Rs. 30 more	Cost = Rs. 60 more	Cost= Rs. 60 more

FOR **OFFICE VAN** USERS

Car ownership YES NO
Bike ownership YES NO

PLAN A	PLAN B	PLAN C	PLAN D
BUS/QINQUI	BIKE	3-WHEELER	CAR
Time = Same	Time = 30min less	Time = 20 less	Time = 20min less
Cost = Rs. 80 less	Cost = Rs. 60 less	Cost = Same	Cost= Rs. 30 less

FOR **3-WHEELER** USERS

Car ownership YES NO
Bike ownership YES NO

PLAN A	PLAN B	PLAN C	PLAN D
BUS/QINQUI	BIKE	OFFICE VAN	CAR
Time = 20 min more	Time = 10min less	Time = 20 more	Time = same
Cost = Rs. 70 less	Cost = Rs. 60 less	Cost = Same	Cost= Rs. 30 less

Average Late time faced in minutes	O -5	5 - 10	10 - 15	15 - 20	20 - 25	25 - 30	30 or more

Income Range	500-10K	10K-30K	30k-50K	50-100K	100K +

Appendix B: Mode Choice Models for Activity Purpose

The table below shows the results of mode choice models developed individually for each activity type. Travel Time was used as explanatory variable and travel mode as the response variable in the model.

Table B1: Mode and Travel time Coefficients

S.No	Purpose	Percent Concordat	β NM	β bike	β car	β taxi	β van	β bus	β TT
1	Home	70.5	1.2603	2.1523	2.4525	2.6289	3.158	10.5717	-73.2831
2	Work	67.3	0.7069	1.9622	2.2992	2.4545	2.7365	8.8933	-70.7326
3	Education	67.9	2.0745	2.3992	2.5342	2.6426	3.9852	-	-96.3168
5	Shopping	61.9	1.1211	2.0424	2.6231	3.0396	3.1852	11.49	-73.98
6	Eating	64	0.5317	1.5789	3.3701	3.9378	4.2933	-	-84.4387
7	Religious	67.6	2.6114	3.3485	3.7872	4.1555	4.4761	-	-75.6311
8	Social	59.6	-0.2653	0.8339	1.5935	2.3112	2.9946	-	-51.5665
9	Relatives	67.1	0.4743	1.7606	2.4657	2.9577	3.1069	-	-73.3263
10	Accompanied	53.1	0.439	1.6181	2.6745	3.2138	3.53	-	-62.9012
11	Recreation	62.8	0.3316	1.4968	2.927	3.2664	3.8883	-	-64.8321
12	Medical	59.7	-0.0244	1.0758	1.6222	2.6895	2.7414	8.7636	-54.5228
13	Other	66.5	1.5749	2.3352	2.8344	3.0749	3.2671	10.0369	-69.0023
14	General Model	69.5	1.2354	2.1501	2.468	2.6471	3.1694	10.2912	-76.1983

Appendix C: Modal Split for Work Trips through Utility Function

The figures below shows the probability of transport mode usage for work trips for different travel time. These are estimated from distinct utility function for each town.

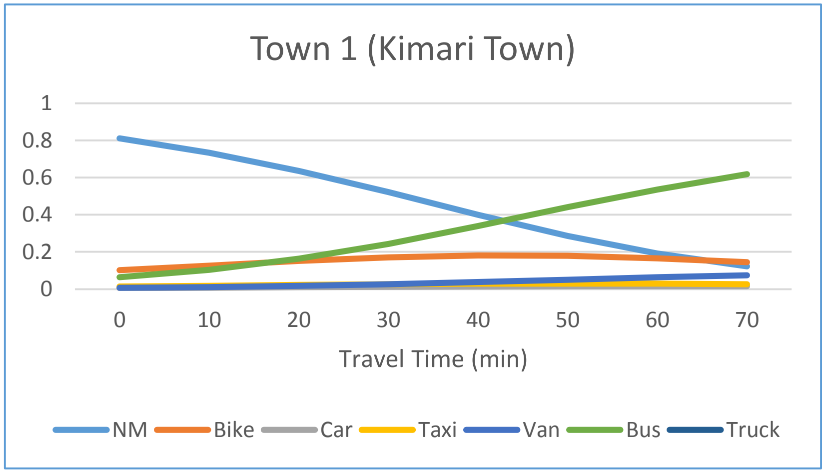

FIGURE C 1 Probability of using specific Mode for Work Trips in town 1.

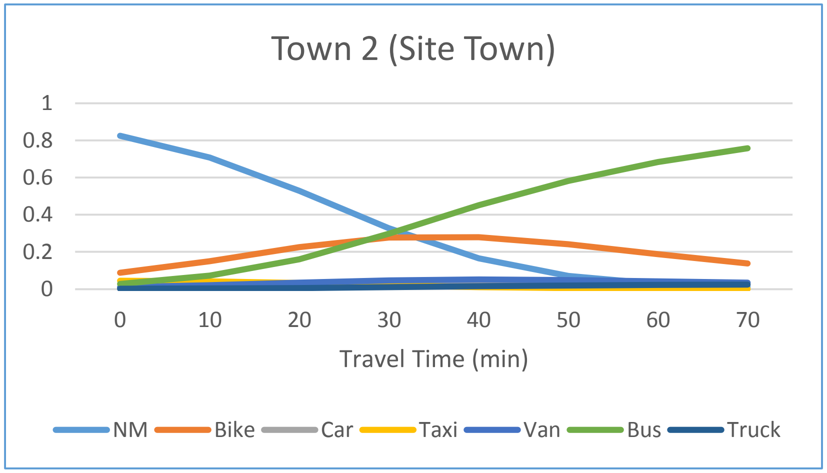

FIGURE C 2 Probability of using specific Mode for Work Trips in town 2.

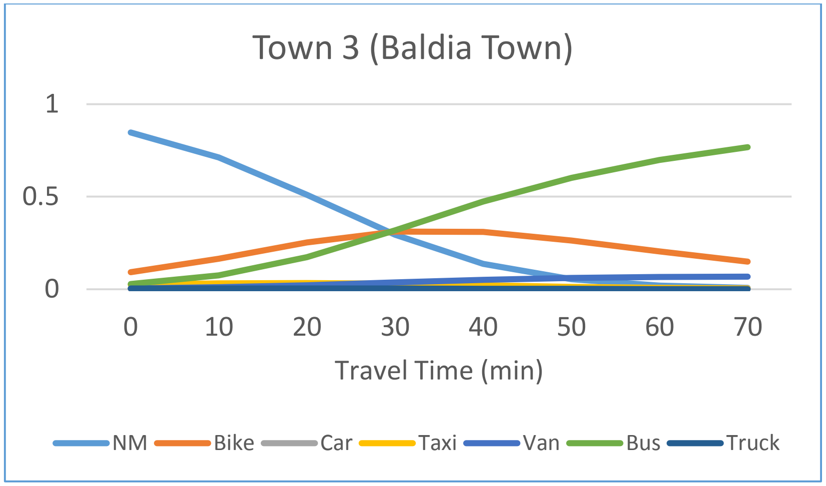

FIGURE C 3 Probability of using specific Mode for Work Trips in town 3.

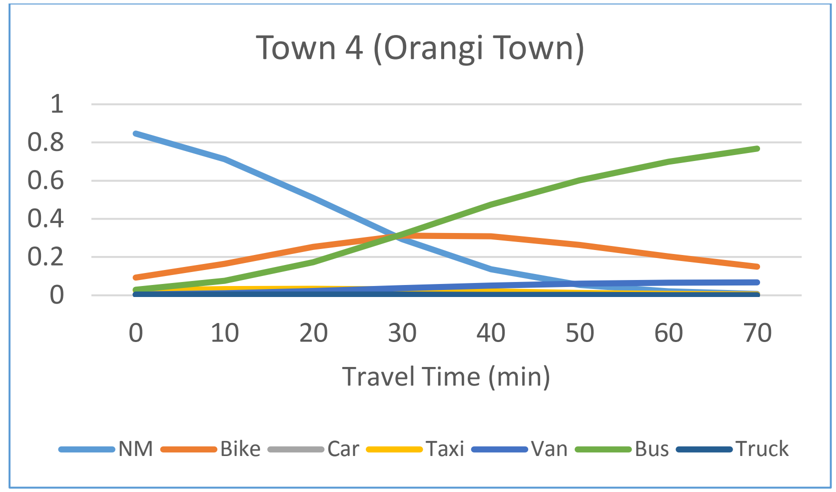

FIGURE C 4 Probability of using specific Mode for Work Trips in town 4.

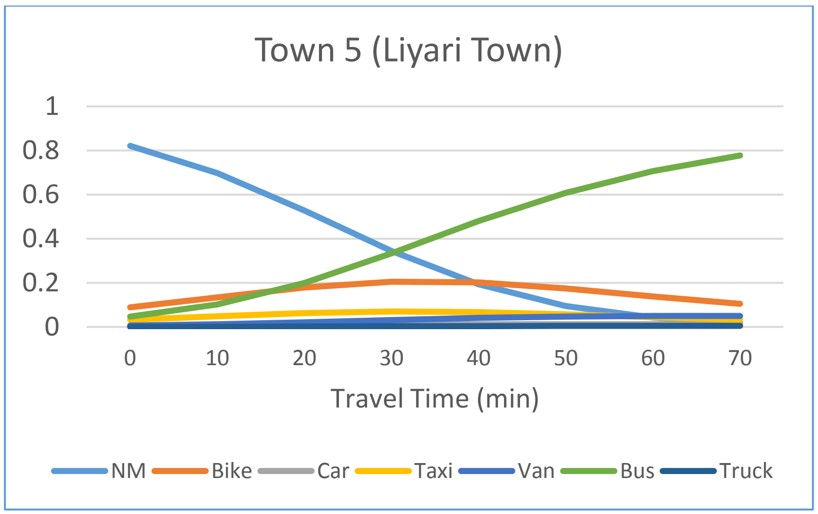

FIGURE C 5 Probability of using specific Mode for Work Trips in town 5.

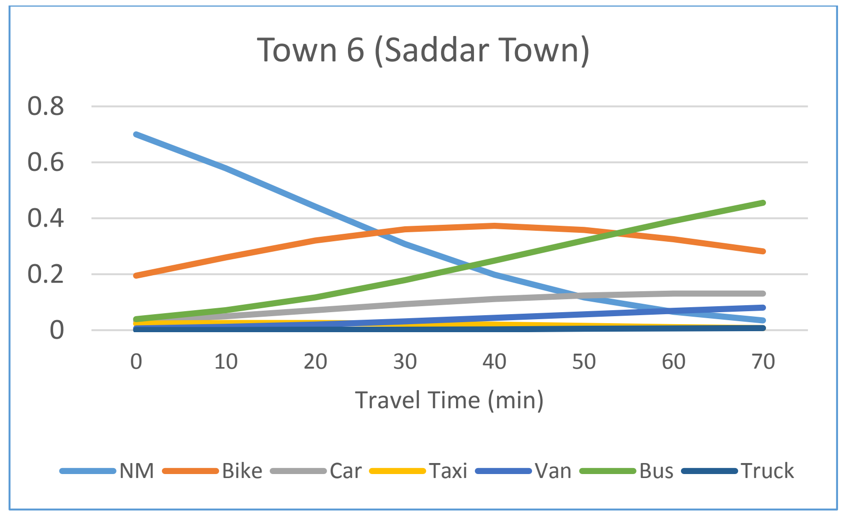

FIGURE C 6 Probability of using specific Mode for Work Trips in town 6.

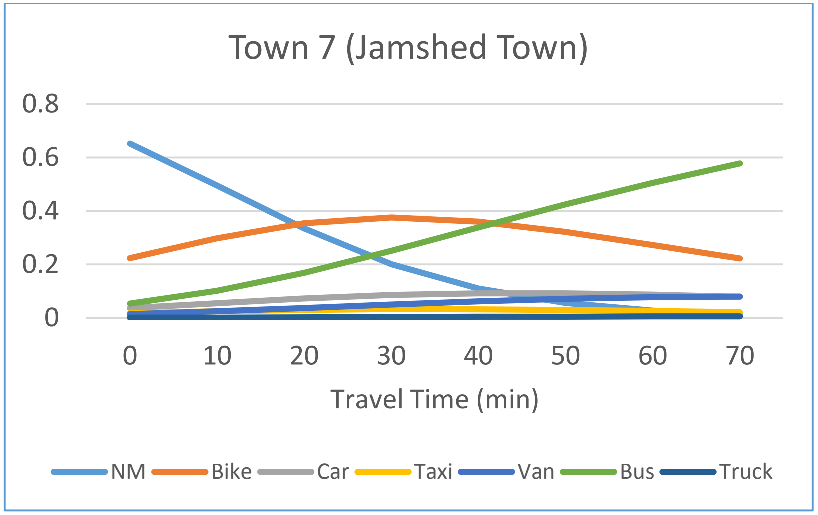

FIGURE C 7 Probability of using specific Mode for Work Trips in town 7.

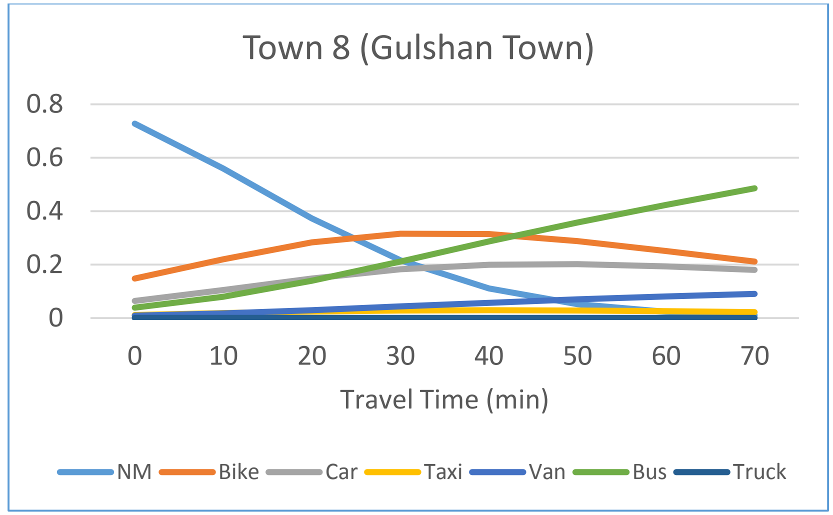

FIGURE C 8 Probability of using specific Mode for Work Trips in town 8.

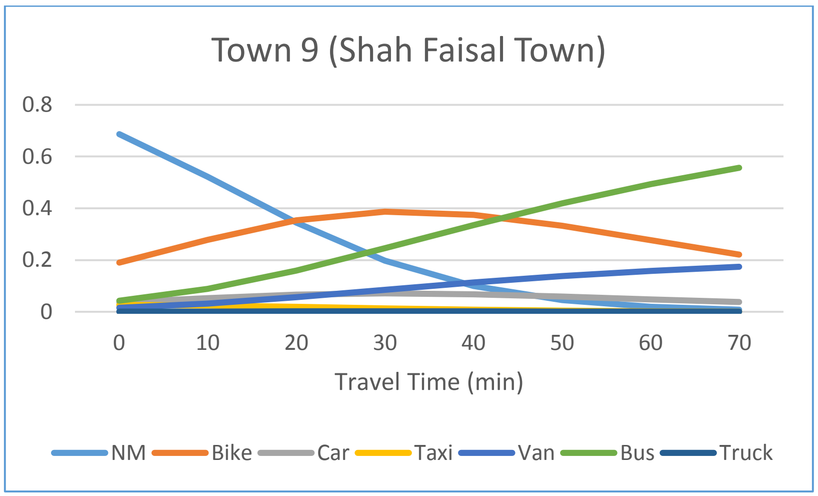

FIGURE C 9 Probability of using specific Mode for Work Trips in town 9.

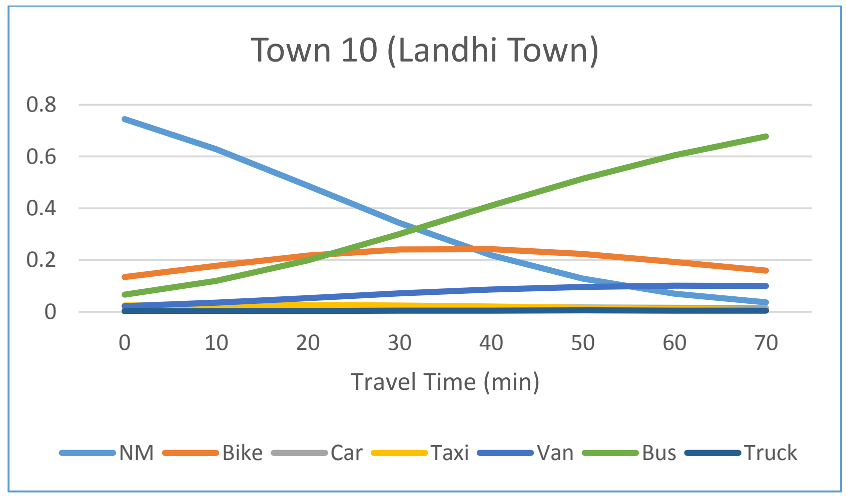

FIGURE C 10 Probability of using specific Mode for Work Trips in town 10.

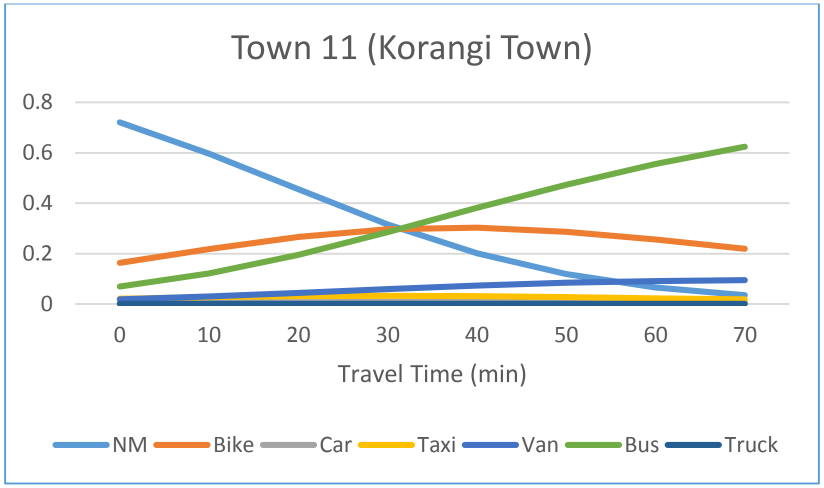

FIGURE C 11 Probability of using specific Mode for Work Trips in town 11.

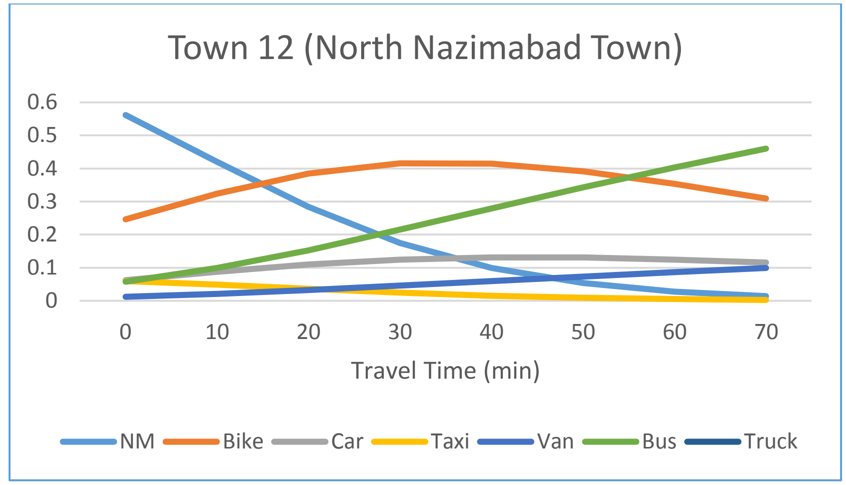

FIGURE C 12 Probability of using specific Mode for Work Trips in town 12.

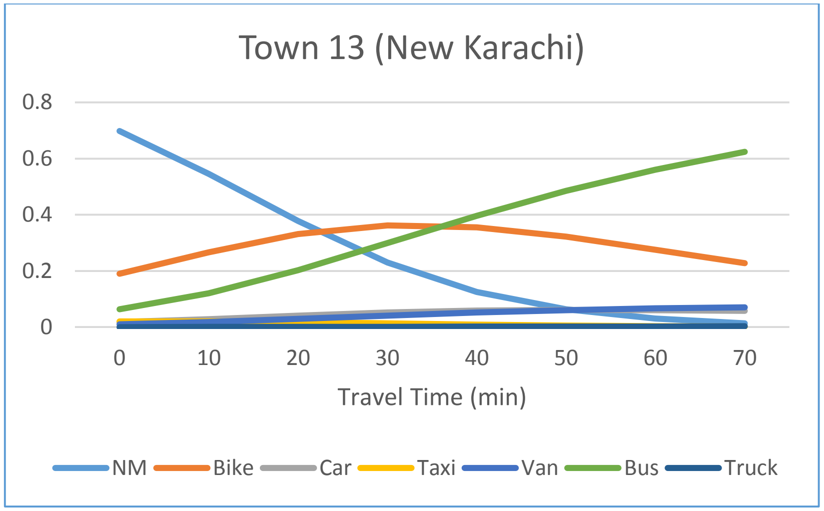

FIGURE C 13 Probability of using specific Mode for Work Trips in town 13.

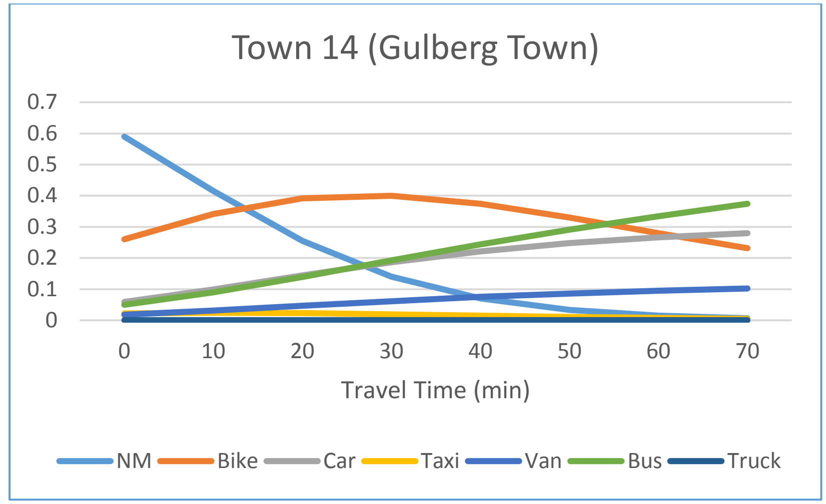

FIGURE C 14 Probability of using specific Mode for Work Trips in town 14.

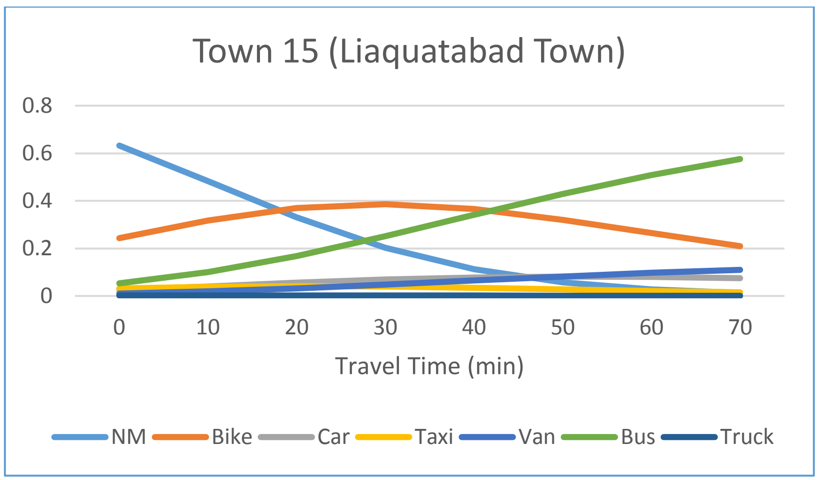

FIGURE C 15 Probability of using specific Mode for Work Trips in town 15.

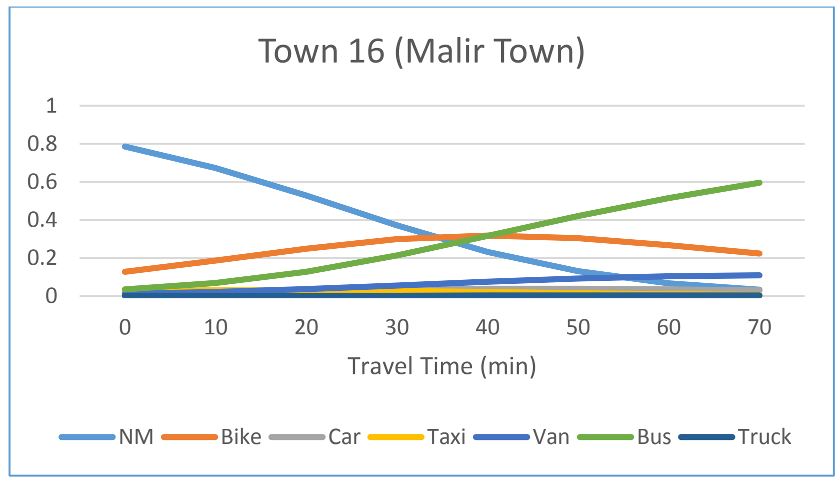

FIGURE C 16 Probability of using specific Mode for Work Trips in town 16.

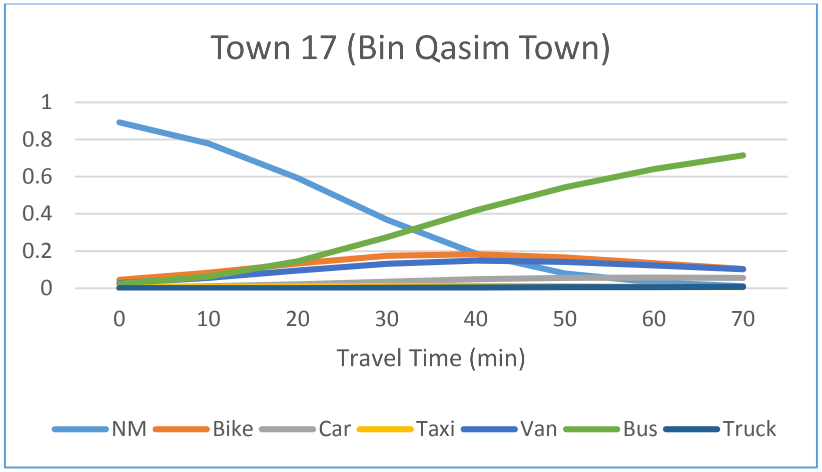

FIGURE C 17 Probability of using specific Mode for Work Trips in town 17.

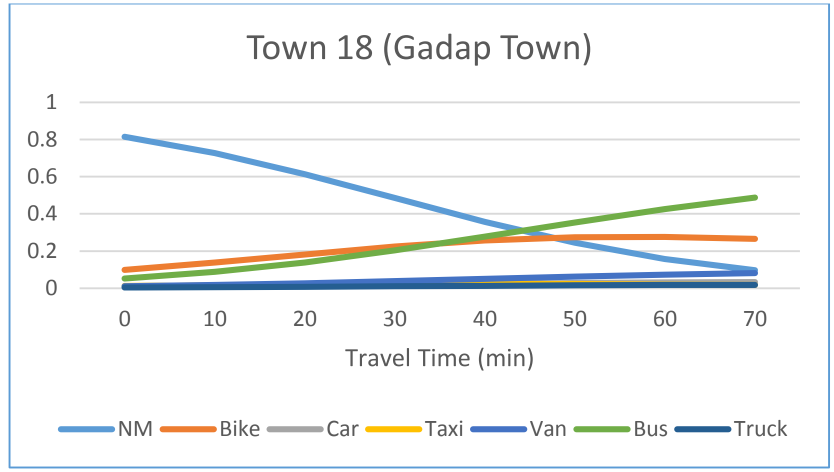

FIGURE C 18 Probability of using specific Mode for Work Trips in town 18.

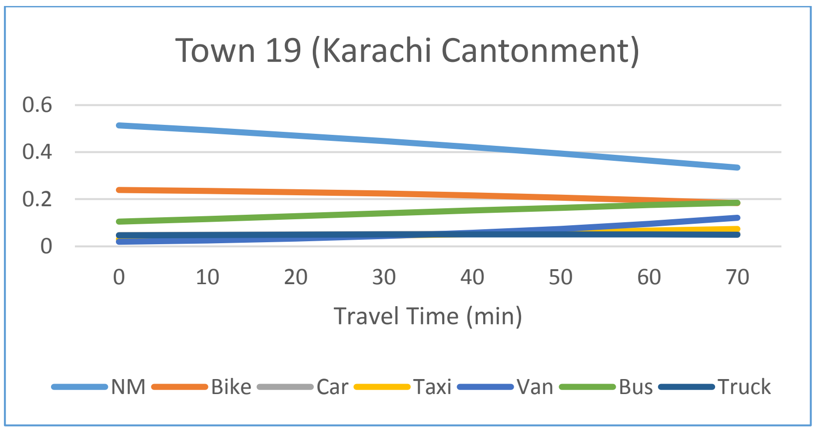

FIGURE C 19 Probability of using specific Mode for Work Trips in town 19.

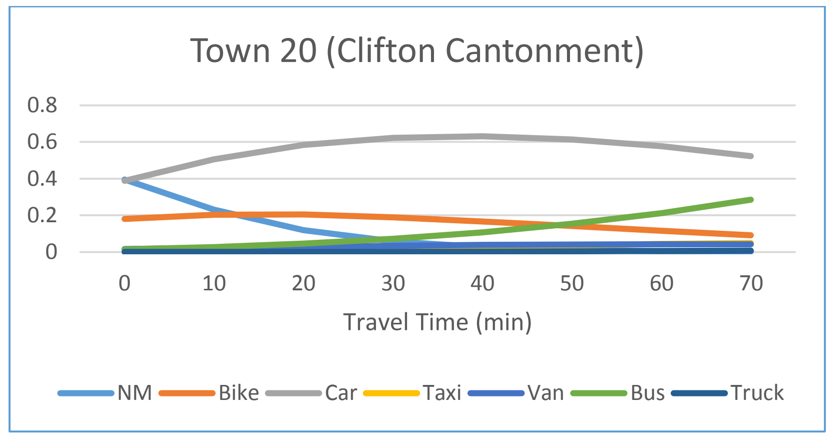

FIGURE C 20 Probability of using specific Mode for Work Trips in town 20.

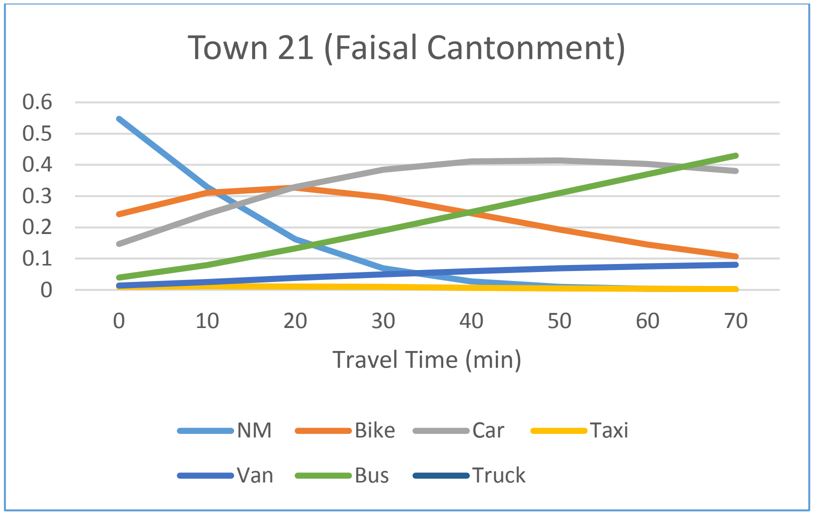

FIGURE C 21 Probability of using specific Mode for Work Trips in town 21.

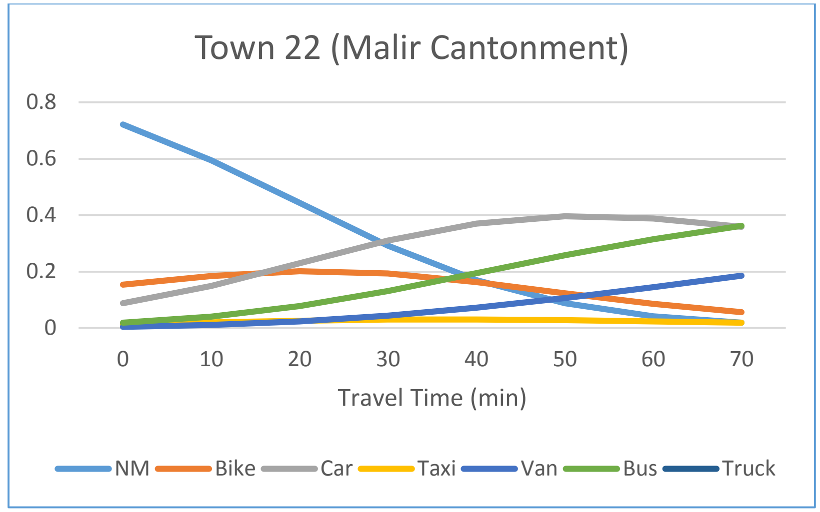

FIGURE C 22 Probability of using specific Mode for Work Trips in town 2.

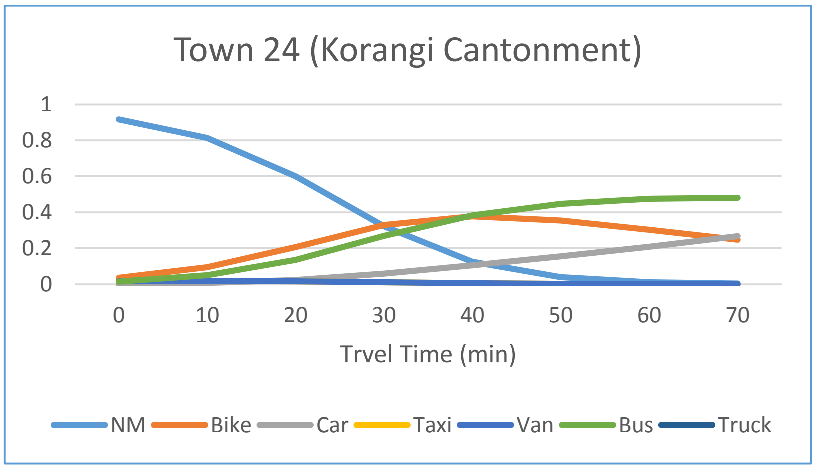

FIGURE C 23 Probability of using specific Mode for Work Trips in town 24.

Appendix D: GIS Maps

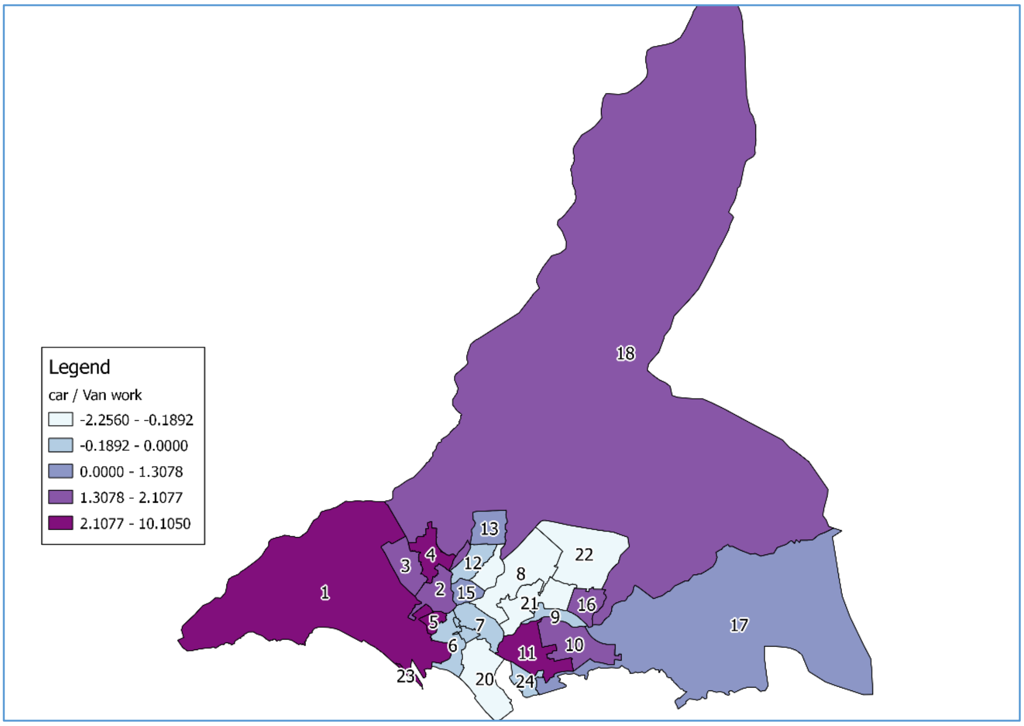

Figure D1 GIS Map of utilizing Taxi/Car for Work trips.

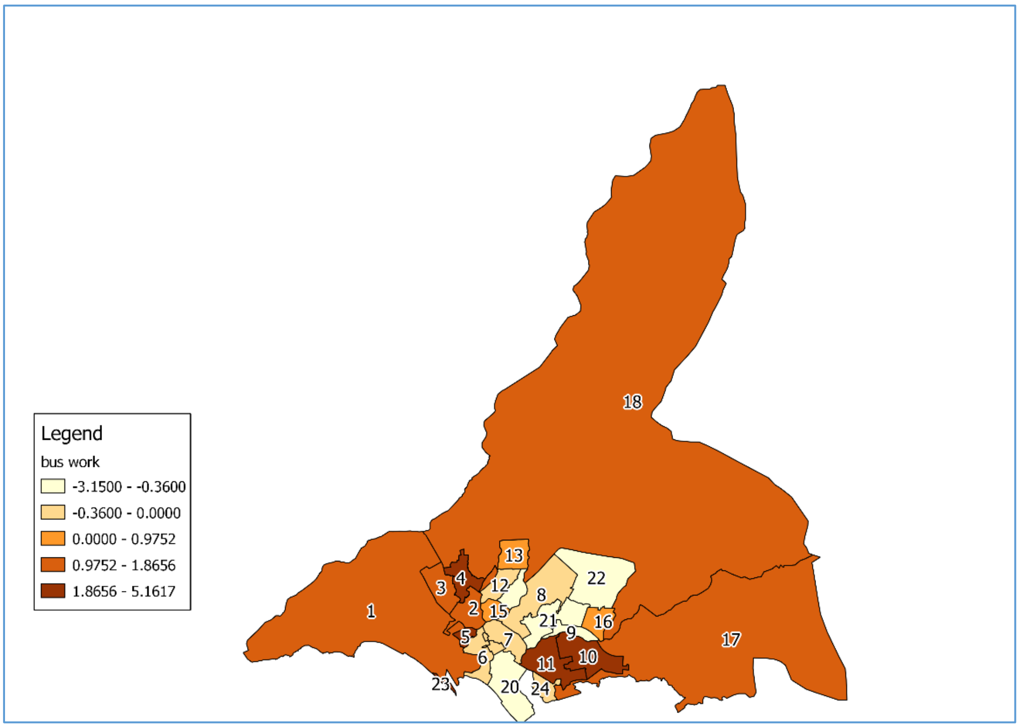

Figure D2 GIS Map of utilizing Bus/Car for Work trips.

Appendix E: Online Questionnaire Survey

Part 1 (General questions)

Q1. What is your Age?

Below 20	21 - 40	41 - 60	Above 60

Q2. What is your gender?

Male	Female

Q3. Household Location

Kimari Town	New Karachi
Site Town	Gulberg Town
Baldia Town	Liaquatabad Town
Orangi Town	Malir Town
Liyari Town	Bin Qasim Town
Saddar Town	Gadap Town
Jamshed Town	Karachi Cantonment
Gulshan Town	Clifton Cantonment
Shah Faisal Town	Faisal Cantonment
Landhi Town	Malir Cantonment
Korangi Town	Manora Cantonment
North Nazimabad Town	Korangi Cantonment

Q4. Employment Status

Employed	Unemployed	Student

Part 2 (Travel Information)

*Q5. Which transport mode do you use while travelling to work?

Car	Bike	Bus	Walking	Rickshaw	Qinqui	Other

*Q6. How many work trips you perform per week?

less than 1	1 - 2	3 - 4	5 or above

***Q7. How many educational trips you perform per week?

less than 1	1 - 2	3 – 4	5 or above

Q8. What is your average travel Cost per month in PKR (Including fuel, Toll tax, public transport fare etc?)

less than 2000	2000 - 4000	4000 - 5000	5000 or above

*Q9. Do you get reimbursement of your travel expenses?

Yes complete refund	Some refund	No refund

*Q10. "I enjoy the time spend commuting to work". Do you agree with this statement?

Strongly agree	Agree	Neither agree nor disagree	Disagree	Strongly disagree

**Q11. "I enjoy the time spend commuting". Do you agree with this statement?

Strongly agree	Agree	Neither agree nor disagree	Disagree	Strongly disagree

***Q12. "I enjoy the time spend commuting to education". Do you agree with this statement?

Strongly agree	Agree	Neither agree nor disagree	Disagree	Strongly disagree

Q13. Are you satisfied with your current travel time or it should be reduced? (1 = Extremely Dissatisfied 5 = Extremely satisfied)

1	2	3	4	5

Part 3 (Stated Preference)

*Q14. Please consider your trip to WORKPLACE while answering the question below.

**Q15. Please examine each of the stated parameter before making a choice.

1

Option 1			Option 2	
Travel Time	60 min		Travel Time	70 min
Travel Cost	80 Rs		Travel Cost	80 Rs
Traffic Congestion	high		Traffic Congestion	Medium
safety	Low		safety	Medium
Walking Time	5 min		Walking Time	10 min

2

Option 1			Option 2	
Travel Time	70 min		Travel Time	70 min
Travel Cost	80 Rs		Travel Cost	100 Rs
Traffic Congestion	Medium		Traffic Congestion	high
safety	Low		Safety	Medium
Walking Time	10 min		Walking Time	5 min

3

Option 1			Option 2	
Travel Time	60 min		Travel Time	60 min
Travel Cost	80 Rs		Travel Cost	100 Rs
Traffic Congestion	high		Traffic Congestion	Medium
safety	Medium		Safety	Low
Walking Time	10 min		Walking Time	5 min

4

Option 1			Option 2	
Travel Time	60 min		Travel Time	70 min
Travel Cost	100 Rs		Travel Cost	80 Rs
Traffic Congestion	Medium		Traffic Congestion	Medium
Safety	Medium		Safety	Low
Walking Time	10 min		Walking Time	5 min

5

Option 1			Option 2	
Travel Time	70 min		Travel Time	70 min
Travel Cost	80 Rs		Travel Cost	100 Rs
Traffic Congestion	Medium		Traffic Congestion	high
Safety	Medium		Safety	Low
Walking Time	5 min		Walking Time	10 min

***Q16. Please consider your trip for EDUCATIONAL purpose while answering the question below.

1

Option 1			Option 2	
Travel Time	40 min		Travel Time	50 min
Travel Cost	45 Rs		Travel Cost	55 Rs
Traffic Congestion	high		Traffic Congestion	Medium
Safety	Medium		Safety	Low
Walking Time	5 min		Walking Time	5 min

2

Option 1			Option 2	
Travel Time	40 min		Travel Time	50 min
Travel Cost	45 Rs		Travel Cost	45 Rs
Traffic Congestion	Medium		Traffic Congestion	high
Safety	Low		Safety	Low
Walking Time	5 min		Walking Time	10 min

3

Option 1			Option 2	
Travel Time	40 min		Travel Time	40 min
Travel Cost	45 Rs		Travel Cost	55 Rs
Traffic Congestion	high		Traffic Congestion	Medium
Safety	Medium		Safety	Medium
Walking Time	5 min		Walking Time	10 min

4

Option 1			Option 2	
Travel Time	40 min		Travel Time	50 min
Travel Cost	55 Rs		Travel Cost	45 Rs
Traffic Congestion	high		Traffic Congestion	Medium
Safety	Low		Safety	Medium
Walking Time	10 min		Walking Time	10 min

5

Option 1			Option 2	
Travel Time	50 min		Travel Time	50 min
Travel Cost	45 Rs		Travel Cost	55 Rs
Traffic Congestion	high		Traffic Congestion	high
Safety	Low		Safety	Medium
Walking Time	10 min		Walking Time	5 min

*Q17. Please consider your trip to any SHOPPING CENTRE while answering the question below.

1

Option 1			Option 2	
Travel Time	30 min		Travel Time	40 min
Travel Cost	40 Rs		Travel Cost	40 Rs
Traffic Congestion	high		Traffic Congestion	Medium
Safety	Low		Safety	Medium
Walking Time	10 min		Walking Time	15 min

2

Option 1			Option 2	
Travel Time	40 min		Travel Time	40 min
Travel Cost	40 Rs		Travel Cost	50 Rs
Traffic Congestion	Medium		Traffic Congestion	high
Safety	Low		Safety	Medium
Walking Time	15 min		Walking Time	10 min

3

Option 1			Option 2	
Travel Time	30 min		Travel Time	30 min
Travel Cost	40 Rs		Travel Cost	50 Rs
Traffic Congestion	high		Traffic Congestion	Medium
Safety	Medium		Safety	Low
Walking Time	15 min		Walking Time	10 min

4

Option 1			Option 2	
Travel Time	30 min		Travel Time	40 min
Travel Cost	50 Rs		Travel Cost	40 Rs
Traffic Congestion	Medium		Traffic Congestion	Medium
Safety	Medium		safety	Low
Walking Time	15 min		Walking Time	10 min

5

Option 1			Option 2	
Travel Time	40 min		Travel Time	40 min
Travel Cost	40 Rs		Travel Cost	50 Rs
Traffic Congestion	Medium		Traffic Congestion	high
Safety	Medium		safety	Low
Walking Time	10 min		Walking Time	15 min

Note:

* Question asked if Employment Status = Employed

** Question asked if Employment Status = Unemployed

*** Question asked if Employment Status = Student

Appendix F: Research Paper

Estimation of Value of Time for a Congested Network – A case study of the National Highway, Karachi

S. Baqueri[a], W. Ectors[a], M. Ali[b], D. Janssens[a]

[a] *Transportation Research Institute (IMOB), Hasselt University, Belgium*

[b] *Department of Urban and Infrastructure Engineering, NED University, Karachi, Pakistan*

Abstract

Traffic congestion in mega cities is a common phenomenon for developing countries. Numerous studies on congestion cost estimation that aim to quantify their monetary losses have been conducted. Correspondingly, choice models and Value of Time (VOT) assessment through utility maximizing theory are abundantly applied in transport literature. However, estimating VOT on congested routes for work trips is not widely applied yet. To recognize the difference under normal and congested network, the current study focuses on VOT estimation for work trips in an extremely congested network.

The focus of this research is to conduct a VOT estimation of the National Highway, Karachi. It is a 20 km long two-way two-lane arterial road which connects Karachi city with Port Qasim Industrial area and the rest of the country. More than 100 medium and high level industries are located in this region. A large amount of freight transport to and from the port is also observed on this road. The National highway, being the only link to commute to the industrial area, is therefore under excessive traffic congestion.

A stated preference (SP) survey was conducted at various industries located in this stretch. The respondents were asked general questions about current travel practices and preferences based on hypothetical -though realistic- travel attributes. A choice set of four alternative modes based on the currently used mode was presented to each individual. Approximately 700 employees from 16 industries were interviewed. The sample was well distributed with respect to age, socioeconomic status and household locations. The data was utilized in a Multinomial Logistics Regression Model (MNL).

As perceived, the results revealed a strong impact from travel time and travel cost on the (dis)utility of travel. However, their impact was more significant when compared to other studies. These results can be utilized by policy makers to reduce congestion, monetary and time losses through efficient transport planning.

Keywords: Value of Time, traffic congestion.

1. Introduction

The focus of this research is to conduct a VOT estimation for the National Highway which connects Karachi city with the Port Qasim industrial area. It aims on the work trips, as a major share of travelers uses this highway to reach its work place. Traffic congestion and delays on this stretch were quantified to be around 30,000 US$ per day (Mir Shabbar Ali, 2014).

The concept of VOT was introduced by Becker when he proposed the conversion of time into money by assigning more time to work (Becker, 1965). Since then, a lot of research has been carried out that ascertains the impact of commuting purpose in estimating value of travel time. Many researchers including (Belenky, 2011), (CHEN Xumei, 2011), (Camille Kamga, 2014), (Meilan Jiang, 2004) and (Fangshu Lei, 2014) worked on differentiating value of travel time between trip purposes. As per intuition, the highest value of travel time occurs during work/ business trips.

For this research, VOT estimations are made for 'passenger transport' only. Freight transport also passes through the stretch, but its VOT assessment is not part of this paper. The VOT is assessed for private car users and other transport mode users separately. Although it has been previously emphasized by researchers to analyze VOT for

each mode separately (William F. Mcfarland, 1985), there are various reasons for this stand-out approach, the main one being that there is only a small percentage of public transport users. In addition, the bus is the only available mode of "public" transport in this area. Clustering "bus" with "bike" is needed for sound analysis. Moreover, "Company Van" was eliminated from the analysis as its travel cost estimation is an arguable matter in itself. Travel reimbursements vary for each company (25%, 50%, 100% etc.). This particular way of grouping revealed the difference between the VOT of car users and users of other modes.
This paper comprises of four sections. The next section explains the study area followed by data collection and methodology. The last section of this paper is the result and discussion section.

2. Study Area

The National Highway is a 20km stretch which links Karachi to main arterial 'Shahrah e Faisal' at one end, and connects to Port Qasim Industrial Area at other end. It comprises of nine intersections from the 'Start Gate' intersection to the 'Pakistan Steel' intersection. Each section is a two-way two-lane road with a median strip. The average volume per hour is higher than the road capacity (Mir Shabbar Ali, 2014). This network is available for passenger and cargo transport and therefore is under excessive load. More than 100 medium and high scale industries are located in the Port Qasim area. A highly heterogeneous vehicular mix uses this stretch, including vehicles from various private transport, para-transit and public transport modes. Moreover, only motorized transport can be used to reach the work areas as it is separated from the residential areas. In the case of freight transport, heavy trailers traverse all day. There is also an oil depot situated in this area, which sets movement of tank trucks in the same stream. Figure 1 below shows the Google imagery of the study area.

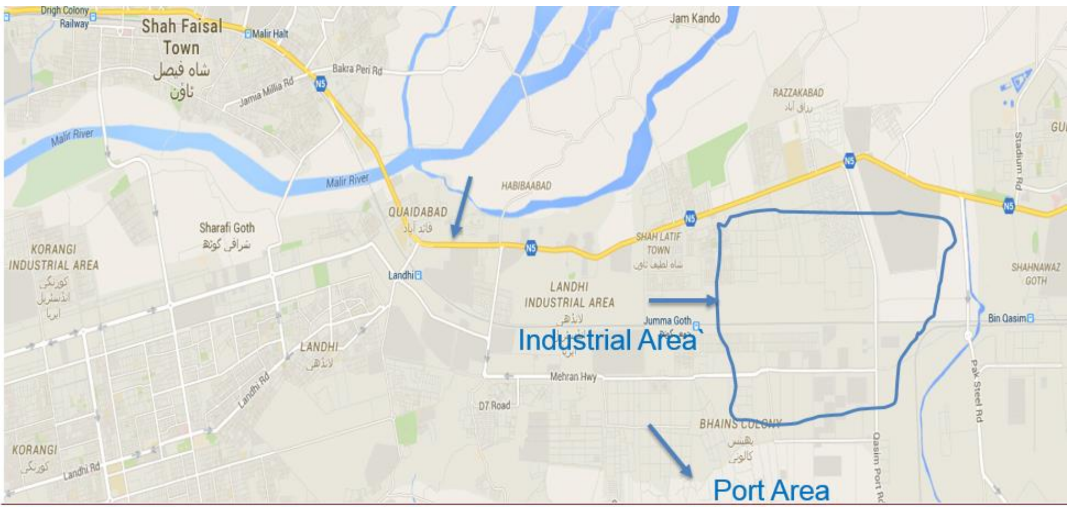

Figure 1: Google Image of National Highway Stretch

3. Data Collection and Methodology

Data for the VOT estimation was collected through a Stated Preference (SP) survey. This survey was conducted at various industries located in the Port Qasim Industrial Area, where employees commute daily on the National Highway. A paper based questionnaire was developed where interviewees were given hypothetical mode options to choose from.
The survey form comprised of two sections. The first section gathered socioeconomic data such as age, gender and income status. Furthermore, travel attributes such as origin, destination, mode, travel expenses and journey time were collected. Journey time was further divided into average, shortest and longest time. Some descriptive questions such as the most common reason for delays and their solutions were asked. There were some secondary questions as well, such as fuel type, number of daily trips, distance travelled and monthly travel expenses.
The second part of this survey was related to SP data. The options from which the respondent could choose were provided based on his current mode. For example, private-car users were given the choice of bike (in case of

ownership), three-wheeler, van and public transport. The travel time and cost parameters in the survey options were realistically formulated, satisfying constraints such as the maximum achievable speed.
The parameters for the alternative mode options are defined as a predefined offset from the reported time and cost. This ensures that the alternative parameters remain stochastic. All the respondents, irrespective of their current mode, were given the same hypothetical choices to choose form, except their current mode, which was eliminated from alternative choice set. In total, there were 5 travel modes (car, public transport, bike, three-wheeler and van). This resulted in four hypothetical choices for each respondent, with the fifth being their current mode.
Other common parameters such as comfort and safety were not included in the survey. As the average speed is identical for each mode, it is hard to discriminate comfort level. Therefore, the attributes for the hypothetical choices were only travel time and travel cost. These were a function of the reported travel time and travel cost. The Table 1 below shows the hypothetical choices and the values provided to respondents.

Table 1: Time and Cost for Alternative modes

Current Mode	Alternative Choice	Travel time [minutes]	Travel cost [PKR] (100PKR = 1US$)
Car	Public Transport	20	-50
	Three-Wheeler	Same	30
	Van	20	-30
	Bike	-10	-30
Public Transport	Car	-20	50
	Three-Wheeler	-20	70
	Van	-10	50
	Bike	-20	30
Van	Car	-20	-30
	Public Transport	Same	-80
	Three-Wheeler	-20	Same
	Bike	-30	-60
Bike	Car	10	30
	Public Transport	25	-20
	Three-Wheeler	10	60
	Van	30	60

4. Results and Discussion

Interviewees were selected through clustered sampling based on the income group. Figure 2 below shows the number of applicants in the dataset with respect to their income group. It should be noted that that the distribution of income among the respondents (the sample) matches the distribution in the real population. This was made possible by asking company's representatives for the percentage of interviewees from each income group.

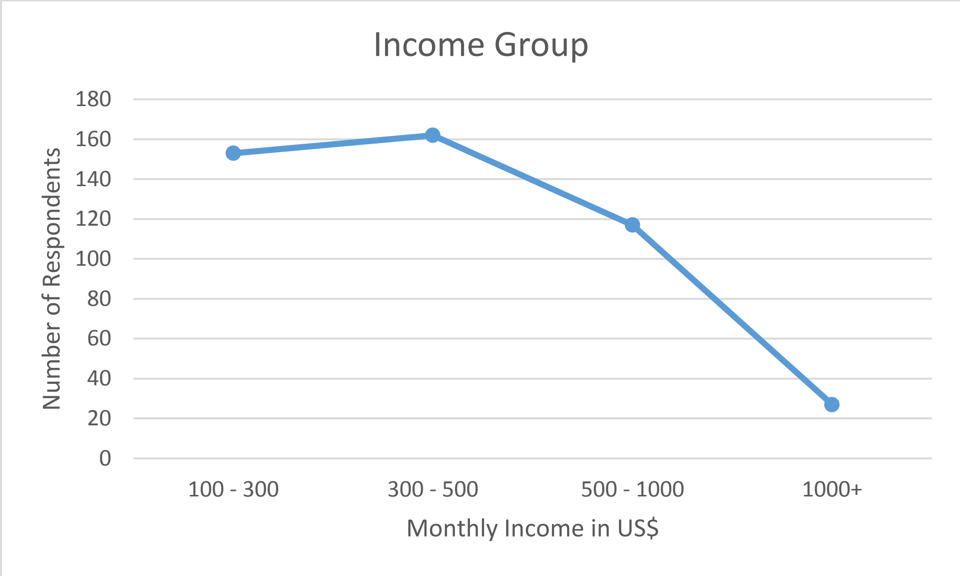

Figure 2: Sample size of Interviewees

Figure shows the alternative (stated) mode selection in function of the actual travel mode. Currently, three-wheelers were not used at all although it was chosen by many respondents as an alternative mode, especially by those travelling by public transport. As seen in Figure , a complex pattern was observed from all passengers. For instance, a majority of those travelling by private car chose the company van as their alternative. Secondly, van passengers mainly opted for a car and a small percentage of them preferred to use a bike. Those travelling by public transport only opted for a three-wheeler or company van as these commuters do not typically own a private vehicle.

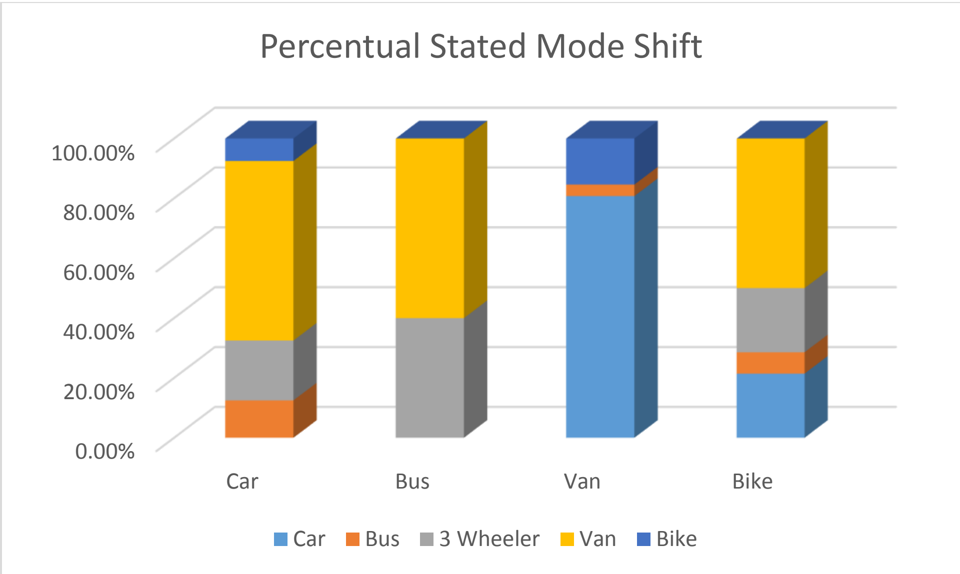

Figure 3: Stated Mode against Current Mode

A Multinomial Logit Regression Model (MNL) was implemented through utility theory by maximizing log-likelihood. There were two utilities for each individual, one for the current and a second one for the alternative mode. The equation below was used for estimating utility.

$$U_i = \beta_0 + \beta_1 . TT_i + \beta_2 . TC_i \qquad (1)$$

Where,

U_i = Utility of mode i (i={Car, Bus, Bike, Van, Public Transport, Three-Wheeler}),
TT_i= Travel time for mode i,
TC_i= Travel cost for mode i,
B_0= Intercept,
β_1= Coefficient of travel time [1/min] and
β_2= Coefficient of travel cost [1/Rs].

Travel cost and time for alternative mode were calculated using the current mode attributes and the properties of the stated preference. The utility was calculated for each individual and alternative. From the utility, probabilities of choosing the current mode were derived for each individual. Lastly, the aggregate log-likelihood (ln) was maximized by the solver extension in MS Excel by optimizing the utility function coefficients.

Travel time increases during congestion and peak hours, which reduces its reliability (Carlos Carrion, 2012). Therefore, travel time and cost for alternative modes were provided stochastic nature (variation) through multiplication with a random variable. This variation in travel time served two purposes. Firstly, it deals with the repetition of identical answers from consecutive respondents (having different travel times) because their trip origins were nearby or even from same location. Secondly it assisted in determining the sensitivity of VOT estimated with change in travel time. This variation in travel time was kept under the limits of variations obtained from the answers of shortest and longest journey time faced. A MNL regression was applied for car users and other mode users separately.
In the equation below, the obtained coefficients of Travel Cost and Travel Time were divided to estimate the value of time.

$$VOT = \frac{\beta_1}{\beta_2} \tag{2}$$

The following values were deduced through the use of the solver function in MS Excel. The Table 2 below shows the average estimated coefficient for travel time and cost after various simulations with different random variations as detailed previously. A negative sign denotes a disutility with an increase in both cost and travel time. However, it is primarily dependent on cost. The constant or intercept is very small and can be considered as insignificant.

4.1 For car users

Table 2: Coefficient for MNL Model of Private Car Users

Coefficient	Value
Constant	-5.6995 E-08
Time Coefficient	-0.1377
Cost Coefficient	-0.0223
Value of time	**3.6677 US$/h**

A log-likelihood ratio test with null-hypothesis a 50%/50% probability (no parameters estimated) shows that the estimated parameters are highly significantly different from zero.

Based on these coefficients the estimated value of time is calculated to be 371.31 Rs/h, which is equivalent to **3.67 US$/h**. Although it is intended for only work trips in a private car, this VOT is higher than in previous studies conducted in similar locations in recent years.

4.2 For other users

Table 3: Coefficient for MNL Model of all users

Coefficient	Value
Constant	-4.026 x E-08
Time Coefficient	-1.8938
Cost Coefficient	-1.1521
Value of time	**0.9752 US$/h**

The Table 3 above shows the coefficients for commuters other than car users. Based on these coefficients, the value of time is calculated to be 98.67 Rs/h, which is equivalent to **0.9752 US$/h**. This value is quite low when compared to the VOT of car users. However, it is still above the average VOT for similar regions. The values obtained are not very sensitive to random variation when travel time is randomly altered by maximum 15 minutes. This can be seen in

Table 4 below where VOT results for 10 different simulations are shown. The VOT remains between 81.9546 Rs/h and 116.1628 Rs/h (equivalent to 0.7773 US$/h and 1.2698 US$/h).

Table 4: VOT results for different simulations

S.No	βTT	βCC	VOT [US$/h]
1	-1.7492	-1.1868	0.8743
2	-2.0056	-1.3034	0.9128
3	-1.8016	-1.1843	0.9025
4	-1.8797	-1.0403	1.0719
5	-1.7688	-1.0979	0.9558
6	-1.4210	-1.0845	0.7773
7	-1.9834	-1.1913	0.9877
8	-1.8181	-1.1799	0.9141
9	-1.9650	-1.0732	1.0862
10	-2.5235	-1.1790	1.2698
		Average =	**0.9752**

The Table 5 below shows estimated country-wide VOT values as a comparison. The VOT varies from region to region but remains below the one dollar mark for all. Amongst them, the lowest value of time is of Pakistan. This study was conducted in Karachi, the same location as that of the present study. However, this particular study covered the whole city of Karachi. Karachi city shows a huge demographic variation; from some posh areas to many slum districts. The people of the districts usually prefer-to-travel by foot to their work. Therefore, as an overall estimation, a VOT of 0.41 US$/h is quite reasonable. Similarly, Farhad revealed diverse VOT values for Bangladesh (Farhad Ahmed K. G., 2004).

Table 5: VOT for similar regions

Country	VOT [US$/h]	VOT [€/h]
India	0.75	0.60
Srilanka	0.56	0.45
Bangladesh	0.72	0.58
Pakistan	0.4 (JICA)	0.32

Interestingly, previous researches such as the one of Kenneth M. Gwilliam have revealed huge intermodal differences in VOT. Kenneth M. Gwilliam also stated that Value of Travel time Savings (VTTS) in congested conditions and other unpleasant situations is higher than under normal conditions in the UK and the Netherlands (Gwilliam, 1997). He compared the VOT for the countries shown in the *Table 6*. Most countries in this list have socioeconomic features similar to Pakistan. The percentage difference between highest and lowest VOT for each country has been calculated, and as a result enormous differences can be observed in VOT between modes. *Table 6* is arranged in descending order according to percentage difference in VOT. The percentage difference of VOT for the current study can be labelled as above average. However, it is slightly less as compared to the neighboring country India.

Table 6 also shows VOT estimations which are higher than the currently calculated VOT values, but the detailed context of these estimations is not available in the research by Gwilliam (1997).

Table 6: VOT (US$) comparison between Modes

S. No.	Country	Car	Pickup	Bus	Truck	%Diff. in high and low VOT
1	Honduras	0.80	1.00	0.14		614%
2	Chile	5.97	8.31	30.89	4.48	590%
3	Srilanka	0.82		0.16	0.16	413%
4	Indonesia	2.06	2.06	0.42		390%
5	India	1.00	0.44	1.80	1.04	309%
6	Uruguay	1.10	1.10	0.29		279%
7	Pakistan (Current Study)	3.66		0.97		277%
8	Kenya	0.51	0.65	0.98	1.93	278%
9	Brazil	4.46		1.28		248%
10	Thailand	1.50		0.50		200%
11	China	0.33	0.12	0.33	0.33	175%
12	Bangladesh	0.91	0.91	0.35		160%
13	Hungary	2.80			6.63	137%
14	Tunisia	1.07		0.48		123%
15	Lebanon	1.72	2.59	1.24		109%
16	Spain		42.29	21.14		100%
17	Venezuela	2.72	2.14	1.66		64%
18	St. Lucia	1.14	1.49	0.91	1.10	64%
19	Korea	2.57		1.70		51%
20	Algeria			2.96	3.37	14%

5. Conclusion

This study, up to the best of our knowledge, is the first of its kind yet undertaken in Pakistan. It estimates the value of travel time in a congested network through utility maximizing approach. This paper reports VOT for work trips under highly congested transport network to be much higher as compared to VOT under normal conditions. VOT estimated for car and other transport mode users was 3.6677 US$/h and 0.9752 US$/h respectively. This study also includes the sensitivity analysis to assess the credibility of VOT estimated and it corroborates to be significantly acceptable. It also compares the difference in VOT amongst transport modes and found it to be consistent with intermodal VOT differences in other study area.

The higher estimations of value of time can be justified with numerous insights. First, this VOT is solely estimated for work commutes. Secondly, only motorized transport can be used to reach the work areas as it is separated from the residential areas. Thirdly, a huge amount of congestion increased the value of unit time saved.

This research provides an important planning insight where project cost and benefits are imperative criteria in determining its feasibility. The results reveal an urgent need for congestion counter measures. In this regard several ‘low cost’ techniques can be applied to reduce the travel time, such as scheduling freight transport in non-business hours. A toll implementation on low occupancy vehicles, in favor of carpooling, can also assist in reducing congestion. Additionally, this paper identifies the gap of VOT estimation for congested transport networks in developing countries; research that is not yet abundantly available in literature.

References

[1] Becker, G. (1965). A theory of the allocation of time. *The Economic Journal*, 493-517.

[2] Belenky, P. (2011). *Revised Departmental Guidance on Valuation of Travel.* Washington: US Department of Transportation.

[3] Camille Kamga, M. A. (2014). Temporal and weather related variation patterns of urban travel time: Considerations and caveats for value of travel time, value of variability, and mode choice studies. *Transportation Research Part C*, 4-16.

[4] Carlos Carrion, D. L. (2012). Value of travel time reliability: A review of current evidence. *Transportation Research Part A*, 720-741.

[5] CHEN Xumei, L. Q. (2011). Estimation of Travel Time Values for Urban Public. *JOURNAL OF TRANSPORTATION SYSTEMS ENGINEERING AND INFORMATION TECHNOLOGY*, 77-84.

[6] Fangshu Lei, Y. W. (2014). A travel time reliability model of urban expressways with varying levels of service. *Transportation Research Part C*, 453-467.

[7] Farhad Ahmed, K. G. (2004). THE VALUATION OF TRAVEL TIME SAVINGS IN LEAST DEVELOPED COUNTRIES: THEORETICAL AND EMPIRICAL CHALLENGES AND RESULTS FROM A FIELD STUDY. *World Conference on Transport Research.*

[8] Gwilliam, K. M. (1997). The Value of Time In Economic Evaluation of Transport Projects; Lessons from Recent Research. The World Bank.

[9] Meilan Jiang, T. M. (2004). Theoretical analysis on the variation of value of travel time savings. *Transportation Research Part A*, 551-571.

[10] Mir Shabbar Ali, M. A. (2014). Estimation of Traffic Congestion Cost-A Case Study of a Major. *Fourth International Symposium on Infrastructure Engineering in Developing Countries, IEDC 2013* (pp. 37-44). Karachi: Procedia Engineering.

[11] Smalkoski, B. R. (2003). VALUE OF TIME FOR COMMERCIAL VEHICLE OPERATORS IN MINNESOTA. *Master thesis FACULTY OF THE GRADUATE SCHOOL; UNIVERSITY OF MINNESOTA.*

[12] William F. Mcfarland, M. C. (1985). the Value of Travel Time: New Elements Developed Using a Speed Choice Model. *Transportation Research Record*, 15-21.

Auteursrechtelijke overeenkomst

Ik/wij verlenen het wereldwijde auteursrecht voor de ingediende eindverhandeling:
Analysis of Value of Time (VoT) and Mode Choice among various regions; A case study for Karachi City

Richting: **Master of Transportation Sciences-Mobility Management**
Jaar: **2015**

in alle mogelijke mediaformaten, - bestaande en in de toekomst te ontwikkelen - , aan de Universiteit Hasselt.

Niet tegenstaand deze toekenning van het auteursrecht aan de Universiteit Hasselt behoud ik als auteur het recht om de eindverhandeling, - in zijn geheel of gedeeltelijk -, vrij te reproduceren, (her)publiceren of distribueren zonder de toelating te moeten verkrijgen van de Universiteit Hasselt.

Ik bevestig dat de eindverhandeling mijn origineel werk is, en dat ik het recht heb om de rechten te verlenen die in deze overeenkomst worden beschreven. Ik verklaar tevens dat de eindverhandeling, naar mijn weten, het auteursrecht van anderen niet overtreedt.

Ik verklaar tevens dat ik voor het materiaal in de eindverhandeling dat beschermd wordt door het auteursrecht, de nodige toelatingen heb verkregen zodat ik deze ook aan de Universiteit Hasselt kan overdragen en dat dit duidelijk in de tekst en inhoud van de eindverhandeling werd genotificeerd.

Universiteit Hasselt zal mij als auteur(s) van de eindverhandeling identificeren en zal geen wijzigingen aanbrengen aan de eindverhandeling, uitgezonderd deze toegelaten door deze overeenkomst.

Voor akkoord,

Baqueri, Syed Fazal Abbas

Datum: **2/06/2015**