



MODE CHOICE MODELLING METHOD TO SHIFT CAR TRAVELERS TOWARDS PARK AND RIDE SERVICE

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ABSTRACT

Urban transportation planning has a key role in the daily routine of inhabitants. Transportation planning has been observed as the most debatable subject, but least attention has been paid on it. Traffic congestion is expanding up to the outskirts of city centers during peak hours. It is perceived as an unresolved urban transportation problem for the inhabitants of urban areas such as Karachi. To resolve this issue, park-and-ride service (P and RS) is considered as a sustainable approach and major contributory in urban areas to reduce the traffic congestion from city centers. P and RS has been successfully implemented and became beneficiary in many countries of the world. Particularly it helps to reduce traffic congestion at a city center, and as a result it reduces the reliability of private vehicles. The objective of this research is to develop a model to shift car travelers' towards P and RS and study the factors which influence car travelers' choice of mode. This study can help stakeholders with useful information for future planning and development of P and RS in Karachi, Putrajaya and Surabaya. The findings revealed the reasons, why car travelers are discouraged to use P and RS facility. Discrete choice modelling is discussed to analyze the factors that encourage users to switch their mode choice towards P and RS. Research outcomes will support policy making and provides base for the future study on the mode choice model for P and RS.

Keywords: mode choice, park-and-ride, travel behaviour, discrete choice, multinomial logit modelling.

INTRODUCTION

"A developed country is not a place where the poor have cars; it's where the rich use public transport", these are the famous words of Gustavo Petro, Mayor of Bogota, Colombia. Since last few decades, the intensity of car travel has increased substantively in all over Europe (MOTIF, 1998). The rapid growth of private car is increasing congestion and pollution. Therefore, it is important to change conventional transportation and lifestyle approaches which create a variety of travel needs. Most of the travelers are now extremely reliant on the car (Anable, 2005). Therefore, the importance of the car is not limited up to a mode choice of transportation, but it is more than that, such as, feelings of the impression, freedom, status, superiority and power (Steg, 2005). Furthermore, the positive use of a car depends on the user's lifestyle and social-spatial engagements (Hiscock *et al.*, 2002). Handy *et al.*, 2005, suggests that certain car users may not always travel because of need, but because of their choice.

Therefore, it is essential to encourage strategies that can decrease the use of private car dependency by providing sustainable replacements. Such strategies may involve advancement in the public transportation system and attract them to use sustainable modes, such as; cycling or walking. Moreover, it is essential to encourage the measures that discourage the usage of a car (Gärling and Schuitema, 2007).

In the early 1990s, several upper-middle income cities of Asia, such as: Bangkok, Seoul and Kuala Lumpur had high income levels, which allowed people to spend more on cars and motorbikes (Barter, 1999). Specifically,

Kuala Lumpur urban areas, although until now the city could not be considered expressively a car dependent, it is in the stage of moderate traffic congestion (Barter, 2004). The percentage of modal split of travels is less than one third by public transport as compare to private transport in Surabaya, Bangkok and Kuala Lumpur cities (Marcotullio and Lee, 2003).

On the other hand, the dense structure of Karachi, Pakistan raise the need to use public and non-motorized transportation (NMT). These approaches are sustainable and reasonable means of transportation for low income people (Ahmed *et al.*, 2008). This can also meet the demand of about 22% of the population of Pakistan which is below the poverty line (Ali, 2006). Asian cities have additional features such as dense populated structure and mixed land-use planning, but following the western cities development trend, such as urban sprawl, developing highways, expressways and a rapid transit system (Ahmed *et al.*, 2008). Therefore, traffic congestion predicting cost, which is currently at \$2.5 billion annually, will reach to \$7.85 billion in coming 10 years in Karachi. This was observed in research conducted by Toyota Research on Traffic Congestion (T-TRC), as a part of their assurance to participate in the sustainability of the society (Recorder, 2013).

Additionally, research endeavors by Whitfield and Coope 1998-9 focused on increasing attraction towards park-and-ride services and said, it would be as effective as traveling in a private car (with switching times). Therefore, it is essential to ponder service regularity and bus precedence methods. Similarly, research in the United Kingdom explores that 81% of



prospective bus travelers believed that a 'turn up and go' level of regularity (at a minimum once every 10 min) was required to encourage them to commute in the service (TAS, 2001). Personal life style and attitude have an important impact on travel behavior (De Vos *et al.*, 2012). Therefore, possible interpretations to deal with low public transport ridership do not simply include improving the quality but also to recognize users' travel behaviors and necessities.

The purpose of this research is to discuss the mode choice model to investigate the factors that influence travelers' mode choice and willingness to shift towards park-and-ride services. In this research, a Multinomial logistic model has been selected and the use of the model will be explained through a case study. It is therefore essential to investigate car users travel patterns and also the willingness to shift the mode if given certain encouragements. The results will be very helpful which provides some awareness into policy makings.

PROBLEM BACKGROUND

Karachi

Karachi, Pakistan, was the fastest growing megacity during the last decade, with an extraordinary 80% expansion of its population growth from year 2000 to 2010 (Kotkin and Cox, 2013). Most of the fastest growing mega cities in past decade belong to developing world (Kotkin and Cox, 2013). Karachi increased 35-times in its inhabitants and about 16-times in its physical expansion since the independence of the country with a per annum growth rate of 5% (Qureshi and Lu, 2007), as shown in Table-1.

Table-1. Karachi metropolitan population and area growth rates (Kotkin and Cox, 2013).

Year	Population (million)	Area (km ²)
1947	0.4	233
1981	5.3	1994
1998	9.8	3527
2004	14.0	3566
2010	20.8	More than 3728

Karachi is known as a leading urban and economic hub of Pakistan, passing through a hysterical phase of quick urbanization and motorization (Qureshi and Lu, 2007). The intensity of urbanization and economic development of the city has put enormous burden on travel demand (Qureshi and Lu, 2007). The increasing travel demand has rapidly occupied the road infrastructure. Motorized vehicles in the country occupy around 33% of roads and highways (Qureshi and Lu, 2007). Figure-1 shows cars and motorbikes dominated on over all vehicle fleet, which is 87% of the vehicles as compared to 7% for

taxis, rickshaws and 1% is public transport (Ali, 2012). Rapid growth in private vehicle ownership and absence of paid parking and road pricing has encouraged enormous traffic congestion, particularly in the city center which grows the average passenger travel time by over 45 minutes (Qureshi and Lu, 2007).

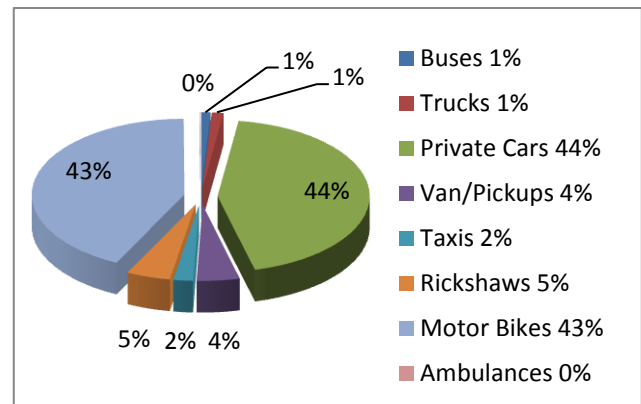


Figure-1. Share of the passenger vehicles' fleet in Karachi-2011.

The urban transportation necessity of the city is cyclic in nature and mainly depend on the travel behavior of the citizens (Ahmed *et al.*, 2008). Table-2 shows the mode shares of Karachi in three different decades by the Traffic Engineering Bureau of Karachi and T-RTC (Toyota Research on Traffic Congestion). Although the trips made by private vehicles are increasing and recently in 2013 a research conducted by T-RTC discovered that almost 60% of the travelers are using their private vehicles such as cars and motorbikes (Recorder, 2013). The noticeable and wondered thing is that buses and mini-buses are still facilitating over the 50% travelers' travel demand. It seems like, the buses have key role in the public transportation of Karachi. Therefore, in Karachi sustainable transportation strategies, infrastructure and accessibility can help to lessen the use of private vehicles.

Table-2. The trend of mode split at Karachi (Qureshi and Lu, 2007, Recorder, 2013).

Year	Mode share (%)		
	Public transport	Private transport	Walking/Cycling
1987	57	31	12
2004	52	48	--
2013	40	60	--

Non-motorized transport such as cycling and walking is known as sustainable but unpopular mode of transport in Karachi, and only rarely preferred by the lower income group who even cannot afford the public transport. The statistics in Table-2 shows the percentage of



journeys performed by walking and cycling in 1987 was 12% and in 2004 no data were found. Reduction in the use of non-motorized transport is because of threatening safety and security issues, lack of policy and planning for pedestrians, cyclists and encroached, ill maintained footpaths (Qureshi and Lu, 2007). Pedestrians are not only victimized of air and noise pollution but also many of them are effected by road accidents. In Karachi, roughly 600 people lose their lives in road accidents every year in which over 50% are pedestrians (Qureshi and Lu, 2007).

It is surveyed that per day around 50, 000 cars are travelling in both directions, which is beyond the existing capacity of roads. Thus, it is essential to take measures for increasing capacity in order to encounter the future needs of the growing demand (Recorder, 2013). Moreover, traffic congestion is increasing day by day and government is focusing on the construction of flyovers, overhead bridges and new express ways (Ahmed *et al.*, 2008). These approaches are increasing the traffic gradually and enhancing the use of private transport (Qureshi and Lu, 2007). Government is adopting conventional approaches which encourage the car users, rather than applying a sustainable approach such as park-and-ride service (Qureshi and Lu, 2007). Therefore, there is a huge imbalance in the modal split between public transport and car users (Gakenheimer, 1999, Ahmed *et al.*, 2008, Qureshi and Lu, 2007).

Putrajaya

Malaysia's new federal administrative capital - Putrajaya is a distinctive city from a transportation policy point of view. Putrajaya's explicit policy goal is to achieve a 70-percent share of all travels by public transport to its essential precincts (Nor Ghani Md. Nor and Nor, 2006). Putrajaya has its own significant status in the world. The city is known as the world's first intelligent Garden City (Putrajaya, 2013). This city is an inspiring example of sustainable human development design to meet the needs of the growing nation for at least 300 years (Putrajaya, 2013). Rapid traffic growth and excessive use of private cars is the most important issue for this city (Borhan *et al.*, 2011). Initially, park-and-ride service was developed which is one of the best methods to reduce the intensity of traffic. However, very few private transport users were attracted towards P&RS (Borhan *et al.*, 2011). Therefore, the policy goal of Putrajaya has become difficult to achieve and it seems confronting to the city authority. However, it appears impossible because this goal needs a setback of the current modal shift of 15:85 between private and public transport users (Nor Ghani Md. Nor and Nor, 2006). Currently, modal split is 70 percent for car, 15 percent motorbike and 15 percent of public transport users (Nor Ghani Md. Nor and Nor, 2006). On the other hand, Karachi has no such kind of park-and-ride facility and also no concept of integrated transportation system (Ahmed *et al.*, 2008). People are habitual of using cars which causes traffic congestion in the city centers. Although this research attempts to find such kind of park-and-ride

service started in Karachi, then would private car users influenced to use that service.

Surabaya

Karachi and Putrajaya are compared with Surabaya, Indonesia; Surabaya is the capital of East Java state of Indonesia. This city is known as biggest metropolitan city of Indonesia. It is also known as Heroic City which has its own importance. The authorities of Surabaya are trying to overcome transportation problems and developing sustainable transportation infrastructure. Local government of Surabaya with the collaboration of World Bank is working and implementing many Public transportation projects in which park-and-ride and an integrated transportation hub is on priority (Department, 2010). Therefore, this research stresses on how to attract the private transport users to reduce the imbalance between private and public transport usage in developing countries. To study possible ways, there is need to find out measures that could fit in the travel behavior and habits to motivate the private transport users towards the park-and-ride service.

Furthermore, the summary of the study is to investigate the factors that influence travel behavior and mode choice. The factors which are affecting the mode choice of private and public transport users are: environment, trip, individual, transport, quality and uncertainty specific factors. The researcher followed the procedure in specifying the method of research to attain the required finding for research. In the prespective of the above conversations, the below research questions are materialize to help better understanding and to find measures. Hence, it can attract car users to park-and-ride service for future promotion and development of the service.

- What are the factors that influence the travelers' mode choice in the cities?
- What are the factors that influence travelers' willingness to choose the park-and-ride service?
- How to develop the mode choice model based on determined factors?
- How to demonstrate the determined factors that influence travelers' willingness to choose park-and-ride service.

TARGETED SOCIAL ISSUES AND PROJECT OBJECTIVES

This study has extracted the traffic management solution of the traffic congestion problem through park-and-ride facility in urban cities (Qin *et al.*, 2013, Institute, 2010, Institute for Transport Studies, CPRE, 1998, Seik, 1997). There is an opportunity to develop the park-and-ride service to encourage users for the modal shift from cars to public transport. In developing countries context, less work has been carried on how to attract the car travelers to choose the park-and-ride service (Arup and Accent, 2012). Similarly, several studies were conducted



on Karachi city, such as urban transport equity, sustainable transport strategies and on pedestrian, but less attention has given on park-and-ride service (Qin *et al.*, 2013, Seik, 1997). Likewise, in Putrajaya the current modal split turns opposite and is 15:85 among public and private transport usage. Therefore, there is a need to investigate the factors that influence travelers' mode choice.

Currently, the traffic congestion in Karachi and Putrajaya is result of people driving their cars to work (Ahmed *et al.*, 2008, Qureshi and Lu, 2007, Gakenheimer, 1999, Borhan *et al.*, 2011, Hamid *et al.*, 2008). People cannot be convinced to shift towards public transportation without understanding their travel behavior (Anable, 2005, Elias *et al.*, 2013, Hamid *et al.*, 2008, He *et al.*, 2009, Ho *et al.*, 2008, Phil Goodwin and Gordon Stokes, 2004, Lindstrom Olsson, 2003, Gurcharan, 1996). The imbalance between public and private transport usage has increased now days, thus there is a need to understand how to shift the travel behavior of private car users in public transport, such as park-and-ride service (Qin *et al.*, 2013). Being a part of travel demand management, park-and-ride service extensively has been adopted in many countries and proved to be successful in decreasing traffic congestion and difficulty of finding parking spaces in urban centers (He *et al.*, 2012). Therefore, this research intends to understand car travelers' willingness to use park-and-ride service and the factors that influence car travelers' mode choice and decision.

This research determines how environment, transport, trip, quality and individual specific factors influence the choice of mode. It focuses on the users (only in Putrajaya because P and R service is implemented there) and non-users in Karachi, Putrajaya and Surabaya of park-and-ride service. This study also determines the factors that influence travelers' decision to choose park-and-ride service, and study the possible ways of attracting car drivers to P and RS. Hence, the main objectives of study follow on:

- To develop a mode choice model to shift car travelers to park-and-ride service in Karachi, Putrajaya and Surabaya. Furthermore, to achieve the main objective there is need to conduct a travel behavior survey;
- To determine the factors that influence the travelers' mode choice in the cities.
- To determine the factors that influence the traveler's willingness to use or not to use the park and ride service.
- To model the travelers' determine factors that influence their willingness to use or not to use the park-and-ride service and to evaluate the developed mode choice model.

PROJECT IMPLEMENTATION AND METHODS

This research mainly covers two clusters: users of park-and-ride and private car travelers. It mainly focuses on the employees and working people. Especially those whose work at places in the central business district or the city center of the study areas. In Karachi and Surabaya, mostly private transport users will be focused. On the other hand, in Putrajaya both the private transport users and users of park-and-ride service are targeted. In order to make the study meaningful, the researcher only focuses on the working people relevant to the study area. There is no such kind of age limit for the respondents, because they all are working people. There is also a benefit of choosing working people because they generate their trips on specific timings while going and coming back from their workplaces. Therefore, mostly traffic increases in that particular peak hours timings, which creates traffic congestion in the cities. Almost, all the respondents are educated. The respondents were asked to participate in research upon their wish on a volunteer basis. When they agreed, a self-administrative questionnaire was provided to them. For non-users of P&R service, the questionnaire was provided at their workplaces. However, the travelers of the park-and-ride service were recruited at park-and-ride lots upon their willingness of participation.

The survey from the users and non-users of park-and-ride service conducted and determined the importance of specific variables and willingness to choose the park-and-ride service. Similarly, the survey also collected information of the real trip choices made by the travelers, which is known as revealed preference, and information related to hypothetical situations called stated preference. The stated preferences data will be evaluated to determine the travelers' willingness to use or not to use park-and-ride service.

According to Krejcie and Morgan's renown sample size formula, this study has 382 samples (Krejcie and Morgan, 1970). Ortuzar and Willumsen in 1996 mentioned the sample size for mode choice study should not be less than 250 samples (Ortuzar and Willumsen, 2011). Additionally, the sample size number for this research is divided into four parts. 300 samples for non-users of P and RS will be taken from Karachi, Putrajaya and Surabaya, 100 samples from each city. Similarly, residual 82 samples rounded off into 100 and will be the users of park-and-ride service at Putrajaya. According to a contemporary research of the University of Leeds, England, it was mentioned that the sample must be big enough, to divide it into groups, and each group must have a minimum sample size of 100 (Pathan and Faisal, 2010).

Data will be gathered through survey questionnaires and evaluated in the Statistical Package for Social Sciences (SPSS). SPSS is a world's famous software package used for statistical analysis. The mode choice model is used to know the commuters' selection of substitute with maximum utility. Whereas, the utility depends on the characteristics of substitutes and the



travelers' measured factors. The utility of an alternative i to person n can be written as;

$$U_{in} = V_{in} + \varepsilon_{in} \quad (1)$$

There are two different types of choice models: one is disaggregated model and another is aggregate model (Memon *et al.*, 2014). The Disaggregated (microscopic) model is useful for discrete commuters to explore the factors that have substantial influence in distinct trip making. Therefore, this model consents the estimation of constraints' values, connected with factors which belong with the values of relative importance respective of factors. Lastly, this model can be used in what-if predictions. A sample of commuters is taken for the choice substitutes and their individualities are determined. For individual commuter the likelihoods of selecting each of their alternatives are estimated. The decision of these likelihoods provides the percentage of travelers that will choose specific alternative. Similarly, aggregate (macroscopic) model is the behavior of a number of travelers whose behavior is likely to be similar. This model works normally for these groups. Aggregate model is flexible in usage but gives less information for travel behavior and also, less effective in the results.

CONCLUSIONS

This research promotes the usage of public transportation through the P and R service, as it is an eminent method while introducing sustainable transportation policies. Similarly, it explains that how influencing factors can be determined to implement P and R service. In which, discrete choice model is discussed to investigate the factors influencing travel behavior. Choice model is grounded on the utility theory of travel behavior. The discrete choice model is the best method to examine the factors which have impact on travel behavior of commuters. Discrete choice model can measure different influencing factors such as: weather, comfort, time, cost, quality and environment. It is proved that discrete choice model also can help to explore the influence of other different factors which were hardly measured before. Consequently, current uncertain conditions of developing countries can be considered in mode choice model. This research can support transport planners for future forecasting and development of park-and ride service. This research will support policy-making and enlightens directions for future study on the mode choice and travel behavior model for park-and-ride service.

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