CHOICE MODELLING OF PUBLIC TRANSPORT TO DESIGN TRANSPORT POLICIES FOR URBAN MOBILITY IN PAKISTAN

Ajaz Ahmed & David Palma

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ABSTRACT

Public transport is vital for socioeconomic development as it allows citizens to access opportunities, including, markets, social interaction, education, and other services, enabling them to rise out of poverty and overcome social exclusion (GOP, 2018). However, Pakistan lacks a decent and affordable public transport system for its citizens. This issue is particularly serious in urban areas due to the expansion in urbanisation, cities economic potential, generation of greater economic activity and subsequent need for mobility and commuting. Using choice modelling and primary surveys, this study investigates commuters' preferences for different attributes or features of public transport and their willingness to pay for fare in three main cities of Pakistan (Islamabad, Lahore and Karachi).

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INTRODUCTION

Public transport is vital for socioeconomic development as it allows citizens to access opportunities, including, markets, social interaction, education, and other services, enabling them to rise out of poverty and overcome social exclusion (GOP, 2018). However, Pakistan lacks a decent and affordable public transport system for its citizens. This issue is particularly serious in urban areas due to the expansion in urbanisation, cities economic potential, generation of greater economic activity and subsequent need for mobility and commuting. Despite rapidly growing population and economic, social, and environmental benefits of public transport; investment in this sector has been largely neglected. Pakistan has a population of around 210 million, roughly 36% of which resides in cities which is expected to reach 50% by 2050 (GOP, 2017). Considering that a good public transport system is fundamental to the sustainable urban development of Pakistan, there is a need to transform Pakistani public transport into a more modern, sustainable, and effective one (GOP, 2018).

The existing public transport options in Pakistani cities are limited, disorganized, inappropriate, and inefficient, which have serious implications for citizens' mobility and their productivity and social wellbeing (Adeel et al. 2016). Furthermore, public transport in urban areas is generally slow, unsafe, and inconvenient due to inappropriate modes of transport managed by individuals in an unregulated environment (GOP, 2018). This puts commuters' safety at risk in addition to discomfort, a wastage of their precious time, and low labor productivity. Similarly, there are fewer routes that do not cover the main areas of the cities, impeding commuters' equal access to public transport (Adeel et al. 2016). This discourages commuters to use whatever available public transport options are and results in a distaste for public transport. In addition to the hassle and tediousness that people endure, the economic cost of a lack of affordable and efficient public transport system is untenably high.

While few mass transit systems have been installed in the Pakistani cities, they are not socially optimal due to expensive infrastructures and a limited coverage (Qureshi & Huapu, 2007; Imran, 2009; Masood et al., 2011). Thus, there is a greater use of car and taxi service which has not only increased the cost of mobility, but also resulted in road congestion and pollution and increased gender and class inequality. A lack of decent and affordable public transport system deters labor force participation and effectual use of time and human resources which have serious implications for individual workers, businesses, and overall society. The private sector has rushed in to fill the gap with ride-hailing services, which are relatively comfortable and efficient, but these services are unaffordable for the low-income groups and again operate in a largely unregulated environment.

There is a lack of coherent institutional framework for public transport in Pakistan (GOP, 2018) that can properly engage and facilitate the key stakeholders to design and implement an inclusive, affordable, and efficient public transport system. Therefore, there is a need to use more novel approaches such as the use of market-based mechanism to incentivize the private sector to invest in bus rapid transit systems to make cities more inclusive, diverse, competitive, commuter-friendly, and livable. Using a stated preference survey and discrete choice modelling approach, this research aims to investigate the citizens' preferences and their willingness to pay for the key attributes of the public transport system in three major cities of Pakistan (Karachi, Lahore and Islamabad). The results of this research would help in designing economically efficient and socially optimal practical solutions to the problem of public transport using novel approaches such as market-based mechanism which is based on the idea of economic incentive schemes that has the potential to transform the urban mobility in Pakistan.

1.1 Research Objectives

This research has three specific objectives.

- To investigate the commuters' preferences of key attributes of a public transport system in major Pakistani cities to establish the optimal trade-offs between key attributes.
- To estimate commuters' monetary valuation, i.e. willingness to pay, for different attributes of public transport, identifying the most relevant aspects of public transport system that influence their choices.
- To make some policy recommendations on the design and optimal characteristics of a transport service in Pakistani cities for the relevant authorities and stakeholders.

In what follows is the description of the process of research which have been carried out so far to achieve the above stated research objectives.

LITERATURE REVIEW

Citizens' choices of the attributes of public transport has been studied extensively in the choice modelling literature. Since the seminal work by McFadden (1974), discrete choice models (Train, 2009) have been used in many areas, such as transport (McFadden 1974), health (de Bekker Grob et al. 2010), food choices (Palma et al. 2017), tourism (Geoffrey & Louviere, 2000), and education (Holdsworth & Nind 2006). Choice models are used to understand and predict individual choices with regards to public transport (e.g. whether individuals will travel by public or private modes of transport), and to measure the monetary valuation of different features of public transport. One notorious application of the later is the calculation of willingness-to-pay (WTP) for attributes of an alternative. For example, in the case of transport, it is possible to calculate the WTP for a reduction in travel time, a value that is known as the subjective value of time (SVT).

In the case of travel mode studies, the most essential attributes to include are travel time and cost (Batley et al. 2019). Traditional work on the subject focused on the impact of fare, access, waiting and travel time on mode choice (McFadden, 1974) finding, for example, that access and waiting time are more onerous to individuals than on-vehicle travel time. More recent work has focused on the impact of perception and subjective factors on mode choice (Hensher et al. 2013), such as crowding (Li & Hensher 2011, Varghese & Adhvaryu 2016), transfers between buses or different modes (Navarrete & Ortúzar 2013), deliberate planning and car habit (Nordfjærn et al., 2014), information availability (Molin & Timmermans 2006), environmental friendliness (Khoon & Ong 2015) and security (Fan et al 2016, Allen et al. 2019), among others (Gruyter et al 2019). Another aspect capturing attention among academics and practitioners in recent times is the use of emerging transport modes, such as smart modes (Choudhury 2018), adaptive transport services (Morsche et al 2019), mobility as a service (Ho et al. 208), and ride-pooling services (König & Grippenkoven 2020).

In the case of developing countries (specific to Asian context), few studies have been conducted which investigate spatial transferability of mode choice (Santoso & Tsunokawa, 2005), methodological approaches of transferability analysis of work trip mode choice (Santoso & Tsunokawa, 2010), the psychological factors influencing the transportation mode choice in six Asian countries including Japan, Thailand, China, Vietnam, Indonesia, and the Philippines (Tan Van et al, 2014). Similarly, Le Loo et al (2015) investigated the users' perception of transport mode use and travel behaviour as a case study for Johor Bahru, Malaysia. TUAN. Vu (2015) also explored the pattern of travel behaviour and mode choice in the context of Vietnam. Munshi, (2016) studied the relationship between built environment and mode choice in Indian context and found that there is a tendency to pre-select residential location choice to enable the use of particular mode.

While there are a few studies on public transport in Pakistan, we could not find choice modelling studies on the attributes of public transport which could design the policies. Using binary logit and count models Adeel et al. (2016) studies the choice between private and public transport modes, as well as activity participation in Rawalpindi Islamabad Metropolitan area. They find poor accessibility and high cost of public transport to be an important deterrent on activity participation, especially in the case of women. Women are more affected because public transport is perceived as unsafe and it requires walking long distances to access it. This leads women to prefer private modes, but they are more expensive and therefore out of reach for most women, who lack a personal income. The analysis of gender bias in transportation and activity participation in Pakistan by Adeel et al. (2017) highlight that women travel mostly by walking, and have therefore limited mobility, especially as their travelling is often socially constrained.

Ullah et al. (2019) studied the acceptance of car sharing systems among residents of Peshawar by asking survey participants to choose among a car sharing scheme, their personal car, regular taxi, or bus to commute. Alternatives were only described based on their travel time and cost, and no pivoting (customisation based on respondents' characteristics) was performed. Research shows a high willingness to accept car sharing schemes, especially among women and higher income individuals, and when travelling with other family members or friends. However, authors do not report a subjective value of time (SVT), which is a gap in this research.

A study by Ali et al. (2020) investigate parents' preferences for travel mode for their children, for example, when picking-up or dropping-off them at school in Lahore. Authors use a multinomial logit model to study respondents' preferences, and describe alternatives based on their travel time and cost. They find a generalised dislike for public transport due to its low accessibility and perceived lack of safety. Higher income respondents prefer using their private vehicles, and most participants perceive ride-sharing services (such as Uber or Careem) as a potential replacement to private car, if new laws ensure appropriate policy and safety. However, the scope of this research is limited as it focuses school children pick and drop service.

A study by Memon et al. (2021) investigated the mode choice modelling to shift car travellers towards the park and ride services in the city centre of Karachi. They have developed mode choice model and implemented on the data that were collected by self-administered structured questionnaire by using logistic regression model. Study unveiled that roughly more than 70% survey participants are willing to adopt the park and ride services to avoid mental stress and to protect the environment.

The present research seeks to improve over previous studies mainly in three ways. First, this study will employ discrete choice modelling using the experimental designs which will maximise the amount of information from each respondent in addition to increasing realism. Second, the survey for this research will be administered in multiple cities to model the citizens' choices of public transport attributes, allowing for comparison of choices across the cities, and improving representativeness of the results. Third, the present research will incorporate a larger number of public transport attributes than previous studies, enabling a more comprehensive analysis of commuters' choices. This will also allow the calculation the willingness to pay (WTP) for a range of public transport attributes to make policy recommendations for potential new services. Since this research will calculate commuters' WTP values indirectly (i.e. respondents are not explicitly asked for a figure, instead WTP is derived from their choices) strategic biases are avoided (e.g. respondents declaring a lower WTP hoping to influence the fare of a future service). Finally, we will measure acceptance and WTP for female-friendly public transport services, so as to identify the potential to implement such systems in Karachi, Lahore, and Islamabad.

Since choice modelling research involves selection of the attributes of the good or service that is being investigated and creation of experimental designs to deploy in the survey in addition to a questionnaire, the next section describes the process of attribute selection and refinement and creation of experimental design.

MATERIAL AND METHODS

The following sections present the description of the choice modelling methodology deployed in this research.

3.1 Background Information Collection

A comprehensive process was followed to collect the background information relevant to the design of the present research. The background information collection process started from the National Transport Research Center (NTRC), which is the research wing of Ministry of Communication, Pakistan. NTRC provided an overview of the prevailing transport system in the mega cities of Pakistan. The Deputy Chief of Research (Mr Khizer Hayat) kindly agreed to comment on the public transport system. The Deputy Chief elaborated the overall public transportation in the whole country, and also discussed about the coordination between provincial transport departments with and federal government. This was followed by a visit to the District Administration office of Islamabad, where a meeting was arranged with the Secretary Transport, Islamabad Transport Authority (Ms. Ayesha). The Secretary Transport explained the public transport routes, transport modes and the fare structure. These two meetings augmented and in some cases updated the secondary information that was collected from various sources regarding public transport in Islamabad.

The Sectary Punjab Transport Authority office was contacted to gather the information about public transport routes, modes and fare structure in the mega cities of Punjab. Furthermore, since Punjab Mass Transit Authority (PMTA) is covering most of the public transport provided by the government, PMTA office was also visited. PMTA provided published documents and data regarding fare and routes covered by the Metro bus, Speedo and Orange train line in Lahore. The gathered information and meetings with officials had revealed that Punjab Mass-transit Authority (PMA) is a regulatory body set up by the Government of Punjab to plan, construct, operate, and maintain mass transit systems in the major cities of Punjab. As such, PMA runs the entire Lahore Metro-bus Service (MBS) along with all of its connecting feeder buses. Lahore Metro-bus Service has become the primary mode of transport now for many locals after it became operational in February 2013. Hence, PMA was also contacted to gather the required information.

At the end, the information about the public transport in Karachi was gathered. For this purpose, initially, the information was gathered from the Sindh Transport Authority and Secretary Transport Office. Additionally, various key informants were also contacted. To collect the background information regarding public transport in the three selected cities, a list of questions was used. This list includes the questions which are relevant to this research and could help in gathering the required information. Three lists of questions (one from each city) along with the reported answers are attached in the Appendix-A of this report. It is also important to mention here that, in addition to the secondary sources, we had also interviewed several commuters in three cities to gather the information which was either not available from secondary sources or we felt the need to double or cross-check it.

The next section elucidates the experimental designs used in this research.

3.2 Attribute Selection and Refinement

The first step to design a choice modelling study after identifying the research problem and research questions is to identify the relevant attributes. The selection of attributes that matter to the study population in a given context is a crucial issue and must involve extensive enquiry to select the attributes that influence individual choices (Hensher et al., 2005). The initial selection of attributes presented in the research proposal was made using a review of literature, i.e. relevant choice modelling studies on public transport, and information from other secondary sources in the Pakistani context. However, to finalize the attributes and attribute levels, we needed to collect additional primary as well as secondary information. This was also required to minimize the unobserved sources of influence on respondents' choice behavior. Attribute levels and alternatives have been identified and refined using the relevant background information.

The selected attributes are measurable and respondents could easily decipher their levels in terms of quantitative scales. Table 1 shows the final attribute table used in the pilots and final survey that is underway in one city. In what follows is the description of the process of background information collection which was used to collect the information to refine the attribute tables.

Table 1: Attribute table for citizens' preferences for public transport

Attribute	Level 1	Level 2	Level 3	Level 4	Level 5
Mode	Van	Minibus	Bus	Metro bus	Car pooling
Access time in minutes (includes walking time at beginning and end of trip)	5	10	15	20	30
Waiting time in minutes	5	10	15	20	30
Travel time in minutes (i.e. in vehicle)	20	30	45	60	90
Transfers	0	1	2	3	-
AC	No	Yes	-	-	-
Wifi	No	Yes	-	-	-
Reserved ladies seats	No	Yes	-	-	-
Service provider/management	Individuals	Private companies	Government	-	-
Fare (PKRs)	15	20	25	30	40

3.3 Experimental Design

The data-generation process for a choice modelling study relies on experimental design. Experimental design is created in a design software and is used to construct the choice situations from attributes and attribute levels to present to the respondents. The design has some statistical properties such as design type, design efficiency, and choice of labelled and unlabelled design. The experimental designs deployed in this research were created using Ngene software which gave output (as per specifications of attributes, attribute levels and alternatives) in the form of code which is used to generate the choice situations. For the present research, the design code from Ngene was copied in Microsoft Excel spreadsheet to create the choice situations. The choice situations were incorporated in the primary surveys along with the questionnaire in the form of choice cards which are choice situations with visuals that help respondents to comprehend the choices. The choice cards presented hypothetical alternatives from which respondents then made the choices. Examples of choice cards are attached in the Appendix-B. The experimental design is created using priors which are tentative values for the parameters to be estimated through the experiment. However, since the values of these parameters are unknown before performing the experiment, first pilot survey is used to obtain the priors. An efficient design was adopted in the pilot as well as final surveys.

The actual levels used in each choice scenario were defined using a D-efficient design (Rose & Bliemer 2009). This kind of designs guarantees a low variance in the model parameters estimated with the collected data, meaning that it maximises the information contained in the choices by each respondent. However, it does require assumptions about the value of the parameters. But as their values are not known at the beginning of the study, the analyst must make educated guests at the stage of the pilot. In the final data collection, it is possible to use the results from the pilot to estimate preliminary values for the parameters. Therefore, for the pilot, we assumed small values in magnitude (0.01), with a positive sign if higher amounts of the attributes benefit the individual (AC, Wifi, and Reserved ladies' seats), or negative if they decrease the benefit of the individual (access, waiting and travel time, transfers, and fare). The D-efficient experimental design used in the pilot is shown in the appendix. While the whole design contained 60 choice scenarios, each individual faced only four of them.

Along with the experimental design, we use a questionnaire and its development is discussed in the following section.

3.4 Questionnaire

As it is done in a choice modelling study, the survey instrument for the present research includes a questionnaire in addition to the experimental design. The questionnaire was drafted using the relevant literature from Pakistan and elsewhere on public transport in general and commuters' choices in particular in addition to the secondary information gathered from different transport departments. The draft questionnaire was shared with experts for the comments. The questionnaire was composed of 22 questions divided in five sections. Below is a short description of the objective and questions in each section of the questionnaire.

- Socio-demographics: Seven question recording city of residence, sex, age, level of education, household size, and income (total and hourly) of the respondent.
- Travel habits: Ten questions recording frequency of travel and public transport use, as well as their expenditure in transport.
- Description of current trip. Respondents were asked to describe the trip they were currently performing in terms of their access, waiting and travel time, as well as their mode transfers.
- Perception of quality of the public transport system. Respondents were asked to rate the current performance of the public transport system in an overall fashion, as well as in nine specific aspects (access, frequency, safety, etc.)
- Car-pooling: Respondents were asked if they were aware, had ever used, and would be willing to use a car-pooling system. A carpooling system, as explained to participants, is a system through which private individuals can contact each other and share rides in private cars.

The data collection during the first pilot revealed that respondent had trouble recalling their hourly wage, and describing their current trip with the requested level of detail. Their evaluation of most aspects of public transport was highly correlated as well, indicating that the level of detail was probably too high for the respondents' attention span. Based on these results, we decided to simplify and reduce the size of the travel questionnaire in the second pilot.

Questionnaire for the second pilot was shortened and simplified. The question about hourly wage was removed. The question asking to describe the current journey was simplified to only ask about the main mode used during the trip and its total length. The evaluation of the public transport was simplified to just three aspects: overall, coverage and frequency for all public transport, and reliability, comfort and safety for each mode in particular. Appendix-C presents both questionnaires, the first questionnaire was used in the first pilot survey and the second questionnaire in the Appendix-C is the final questionnaire used to collect the data.

After development of the survey instrument, we conducted the pilots in the three cities and the next section briefly discusses the pilot surveys.

3.5 Modelling Approaches

To study the behaviour of respondents, we tested multinomial (McFadden 1973) and mixed logit (McFadden & Train 2000) models. The estimated models are based on the Random utility theory, which states that respondents receive a different amount of *utility* (i.e. benefit) from each alternative, and they choose the alternative that provides them the most. The utility, is assumed to be determined by a set of observable explanatory variables (the alternative's attributes and the individual's characteristics), as well as some unobservable factors represented by a random error (e.g. unobservable attributes or restrictions faced by the decision maker). In particular, we defined the utility of each alternative as follows.

$$U_{jtn} = ASC_j + \beta_{AT}AT_{jt} + \beta_{WT}WT_{jt} + \beta_{TT}(TT_{jt}) + \beta_{AC}AC_{jt} + \beta_{WF}WF_{jt} + (\beta_{LSM}(1 - female) + \beta_{LSF}female_n)LS_{jt} + \beta_{FA}FA_{jt} + \varepsilon_{jtn} \quad (1)$$

Where U_{jtn} is the utility of alternative *j* for individual *n* in choice scenario *t*. The Alternative Specific Constant (ASC_j) is a parameter to be estimated representing how attractive each alternative *j* is, if all other observable attributes are kept the same (*ceteris paribus*). For example, imagine a scenario where for a given trip all modes take the same time, cost the same, and are equal in all other attributes. If the ASC for alternative *metro-bus* is bigger than the ASC for alternative *van*, then respondents would prefer *metro-bus*, despite all of its attributes being the same as *van*. In other words, ASC parameters capture effects of unobserved attributes associated to each alternative.

Attributes AT_{jt}, WT_{jt} and TT_{jt} represent the access, waiting and travel time of alternative *j* in choice scenario *t* in minutes. Attributes AC_{jt}, WF_{jt} and LS_{jt} are dummy variables taking value the value one (1) if alternative *j* in choice scenario *t* include Air conditioning, free internet access through wifi, and reserved ladies' seats, respectively; and they take the value zero (0) otherwise. The variable $female_n$ takes the value one (1) if respondent *n* is a woman, and zero (0) if not. FA_{jt} is the fare (or cost) of travelling by mode *j* in choice scenario *t*.

All β parameters must be estimated, and they represent the weight of each corresponding attribute in the utility as perceived by the decision maker. The weight of the ladies' seat attribute was further disaggregated into the utility it provides to men (β_{LSM}) and to women (β_{LSF}). Finally,

ε_{jtn} is a standard Gumbel random error term, representing all factors influencing the choice that are not perceived by the modeller.

Most basic multinomial logit models assume homogenous preferences, i.e. that everyone in the sample has the same preferences. But such assumption is not realistic. There are several ways to introduce heterogeneity in preferences. A simple way is to introduce *systematic preference variations*. This method consists in adding specific parameters for subsamples in the data, for example using a different parameter for male and female respondents. That is what we did when modelling the preferences for ladies' seats using β_{LS} and β_{LSF}.

Another way to introduce heterogeneity in preferences is by assuming β parameters to follow a probabilistic distribution. This implies that all respondents have potentially different preferences, and we only know how these preferences are distributed, but not their precise value. This also implies that we now must calculate the mean and standard deviation of each random β parameter. Logit models with random parameters are called mixed logit models (McFadden & Train 2000). Even though we tested this kind of models, they did not increase fir significantly over the regular MNL models. Furthermore, they led to different specifications for datasets from different cities, making between-city comparisons more difficult. Therefore, we selected a traditional multinomial (MNL) model as the best approach.

The utility function does not have any meaningful unit, in the sense that its origin is arbitrary. To see this more clearly, consider adding a constant to the utility of all alternatives. This would not change the decisions made by the individual, as the order of the alternatives, and the difference between them would remain intact. This has two implications. First, for attributes with multiple levels, the effect of one level must be set to zero (normalised), just as it is done in linear regression with dummy variables. This also means that one of the ASC must be set zero for the model to be identified.

The second consequence of utility not having any meaningful unit is that the value of the β parameters is hard to interpret. For example, in equation (1), an increase of one minute of waiting time leads to a change of β_{WT} units of utility. But as utility does not have any meaningful unit, neither does β_{WT}.

An easier way to interpret results from the model estimation is by focusing on its implied Willingness to Pay (WTP). The WTP is the marginal rate of substitution between an attribute included in the utility function, and its price (fare), also included in the utility. This represents how much money an individual is willing to trade in exchange for acquiring the specified attribute, while keeping the same level of utility. In other words, the WTP amount represents how much money the individual is willing to pay for that attribute. Formally, the calculation is as follows.

$$WTP_k = \frac{\frac{\partial U}{\partial x_k}}{\frac{\partial U}{\partial fare}} \qquad (2)$$

A positive WTP (WTP>0) implies that an individual likes the attribute *k* under consideration and would be willing to pay an increased fare if that attribute was present, while maintaining their utility level. We expect attributes like Air conditioning, Wifi and reserved ladies' seats to have a positive WTP. A negative WTP (WTP<0) implies that the individual dislikes the attribute *k* under consideration and would have to be compensated with a lower fare if that attribute was present or increased to maintain their level of utility. We expect access, waiting and travel time to have a negative WTP.

Another way to compare preferences across models estimated with different datasets is through their Average Marginal Effects (AME). They represent the average change in the probability of choosing an alternative in the sample due to a change in attributes. They are calculated using equation (3) if the attribute under consideration is continuous (e.g. travel time), and equation (4) if the attribute is categorical or a dummy variable (e.g. presence of AC) (Wooldridge 2002).

$$AME_{jk} = \frac{1}{N}\sum_{n}\sum_{t}\hat{P}_{jn}(x_{kjnt} + \delta_k) - \hat{P}_{jn}(x_{kjnt}) \tag{3}$$

$$AME_{jk} = \frac{1}{N}\sum_{n}\hat{P}_{jn}(x_{kjn} = 1) - \hat{P}_{jn}(x_{kjn} = 0) \tag{4}$$

In the equations above $\hat{P}_{jn}$ represents the forecasted probability of individual n selecting alternative (i.e. mode) j, which is a function, among other things, of the value of attribute k on alternative j for individual n and choice scenario t (x_{kjnt}). δ_k is small disturbance, e.g. an increase of 10 minutes in the travel time. Note that in the formula only the k^{th} attribute of the alternative under consideration (j) change its value. All other attributes for all other alternatives remain at the values observed by the respondents during the data collection stage.

AME are expressed as percentage point changes in probabilities, and can therefore be directly compared across models, even if they were estimated using different datasets.

All models were estimated using the software Apollo (Hess & Palma 2019).

RESULTS

The results description starts from the discussion of sample characteristics which is followed by the presentation and discussion of the empirical results of the models estimated using data from final surveys carried out in Islamabad, Lahore and Karachi. Below is the description of sample characteristics.

4.1 Sample Characteristics

Table 2 presents the main socio-demographic characteristics of the respondents across the three cities under consideration: Islamabad, Lahore and Karachi. Around 520 individuals answered the survey in each city. In all cases, men were a majority, with women representing only 23%, 30% and 37% of the sample in Islamabad, Lahore, and Karachi, respectively. In terms of the samples' age composition, Islamabad and Lahore are similar, with over 50% of the sample being between 20 and 29 years old. On the other hand, in Karachi only 27% of the sample is between 20 and 29 years old. The level of education is higher in Lahore with an average of 12.3 years of formal education, followed by Islamabad with an average of 11.6 years, and finally Karachi with only 8.2 years.

Table 2: Sociodemographic characteristics of surveys' participants (Values are %age of the total)

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<tr><th></th><th></th><th colspan="3">Islamabad</th><th colspan="3">Lahore</th><th colspan="3">Karachi</th></tr>
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<tr><td>Respondent age</td><td>10-19</td><td>11</td><td>11</td><td>11</td><td>18</td><td>26</td><td>20</td><td>10</td><td>13</td><td>11</td></tr>
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<tr><td>Education</td><td>None</td><td>2</td><td>1</td><td>2</td><td>2</td><td>3</td><td>2</td><td>24</td><td>31</td><td>27</td></tr>
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<tr><td>(Number of members)</td><td>2</td><td>3</td><td>3</td><td>3</td><td>1</td><td>3</td><td>2</td><td>6</td><td>2</td><td>4</td></tr>
<tr><td></td><td>3-4</td><td>18</td><td>17</td><td>18</td><td>16</td><td>14</td><td>15</td><td>21</td><td>26</td><td>23</td></tr>
<tr><td></td><td>5-8</td><td>67</td><td>71</td><td>68</td><td>68</td><td>72</td><td>69</td><td>53</td><td>60</td><td>56</td></tr>
<tr><td></td><td>> 8</td><td>12</td><td>9</td><td>11</td><td>15</td><td>11</td><td>14</td><td>21</td><td>10</td><td>17</td></tr>
<tr><td>Household monthly income</td><td>0</td><td rowspan="3">74</td><td rowspan="3">59</td><td rowspan="3">0</td><td>9</td><td>25</td><td>14</td><td>7</td><td>7</td><td>7</td></tr>
<tr><td>(PKRs)</td><td>0.1-24</td><td>33</td><td>35</td><td>34</td><td>27</td><td>30</td><td>28</td></tr>
<tr><td></td><td>25-49</td><td>36</td><td>33</td><td>35</td><td>45</td><td>40</td><td>43</td></tr>
<tr><td></td><td>50-99</td><td>21</td><td>36</td><td>24</td><td>18</td><td>6</td><td>14</td><td>13</td><td>17</td><td>14</td></tr>
<tr><td></td><td>100-149</td><td rowspan="2">4</td><td rowspan="2">5</td><td rowspan="2">5</td><td rowspan="2">3</td><td rowspan="2">1</td><td rowspan="2">3</td><td>6</td><td>5</td><td>6</td></tr>
<tr><td></td><td>150-200</td><td>2</td><td>1</td><td>1</td></tr>
<tr><td></td><td>200-399</td><td>1</td><td>0</td><td>1</td><td>1</td><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td></tr>
<tr><td></td><td>> 400</td><td>0</td><td>1</td><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td></tr>
<tr><td colspan="2">Total (respondents)</td><td>408</td><td>123</td><td>531</td><td>360</td><td>155</td><td>515</td><td>326</td><td>194</td><td>520</td></tr>
</table>

Different income thresholds were used in different cities, making it harder to compare across them. When collecting data in Islamabad, the bands were not detailed enough for the low income range. The low income bands were further disaggregated in Lahore and Karachi. Due to this change it is only possible to compare the income level of Lahore and Karachi, but not Islamabad. Respondents from Karachi averaged a monthly household income of 39900 Rs, while respondents from Lahore averaged only 33000 Rs per month.

4.2 Empirical Results

Empirical results include models estimated using the data on commuters' preferences for public transport modes and their attributes from the three cities. While public transport modes vary across the three cities; their attributes, and hence most of the model parameters are similar in the three surveys. This means that most of the explanatory variables in the models are the same across the three data sets. The utility function assumed for model estimation is presented below.

$$U_j = \beta_{0j} + \beta_{AT}AT_j + \beta_{WT}WT_j + \beta_{TTj}TT_j + \beta_{nTra}nTra_j + \beta_{AC}AC_j + \beta_{Wf}Wf_j + \beta_{LS}LS_j + \beta_F Fare_j + \varepsilon_j$$

Where j enumerates alternatives (i.e. transport modes); AT, WT, and TT are the access, waiting and in-vehicle travel times; nTra is the number of transfers between different vehicles of the same mode (e.g. changing from one bus to another); AC, Wf, and LS are dummy variables taking value 1 if the mode has Air Conditioning, Wi-Fi (i.e. wireless internet access), and reserved seats for women available, and zero otherwise, respectively. Fare is the fare of travelling in the giving mode that commuters have to pay, and ε is a Gumbel random error term. All β coefficients are parameters to be estimated.

According the Random Utility Modelling, respondents will choose the alternative that provides them the highest utility. In the utility described above, the β coefficients represent the marginal impact of attributes in the utility. We expect $\beta>0$ for desirable attributes (for example the presence of AC, Wi-Fi and ladies' seats), and $\beta<0$ for undesirable attributes (e.g. fare, transfers, access, waiting and travel time). If $\beta = 0$ (or not significantly different from zero), it means that the corresponding attribute has no impact on respondents' perceived utility. A bigger magnitude of β does not necessarily implies a bigger effect of the corresponding attribute on the utility, as the net effect is also influenced by the magnitude of the attribute (i.e. β^*x, where x is the value of the attribute). Average marginal effects of attributes are presented and discussed later on this text.

The $\beta 0$ parameter is an intercept, also called Alternative Specific Constant (ASC). Their objective is twofold: (i) to capture the average effect of attributes not explicitly included in the utility function (e.g. inherent preference for a given mode), and (ii) to reproduce the observed market share of the alternatives in the sample. The second is a property of MNL models, where the inclusion of intercepts for all alternatives (except for one that takes the role of the base) guarantees that the model perfectly reproduces the observed market shares in the sample.

Table 3 presents the coefficients of the models estimated for each city, as well as their t-ratios and each model's main fit indices. Results reveal that all parameters reach significance (i.e. a t-ratio bigger in absolute value than 1.96) in the Islamabad model, except for the alternative specific constants (ASC), that are only there to reproduce the observed market share and do not have a clear interpretation. . In Lahore, access, waiting and travel times, as well as transfers and fare all achieve significance. However, among the additional services, only AC does. Karachi is the only sample where not all times are significant. Nevertheless, access and waiting time are significant, as is travel time for van, mini-bus and qingqi. The presence of AC is also significantly valued, as are ladies' reserved seats among women. The effect of the fare is highly significant in all models.

Besides the level of significance, log-likelihood function value is also an indicator for model fit and the smallest value is achieved for Islamabad, followed by the Lahore and Karachi. Since all the three cities have a similar number of observations, this fact suggest that the model fit is best for the Islamabad data than the Lahore and Karachi. This phenomena have multiple explanations, for example, (i) data indicates that commuters' preferences in Islamabad and Lahore are more homogenous, as compared to Karachi, (ii) Islamabad and Lahore residents could be more familiar with the transport modes offered as alternatives, due to a relatively better public transport system in these cities as compared to Karachi, (iii) respondents from Karachi are more heterogeneous in terms of preferences and characteristics, or (iv) it could be a combination of the above reasons.

Despite the differing fit of the models across cities; all models achieve acceptable levels of significance, and all of the measured effects point in the expected direction. For example; all access, waiting, and travel time parameters are negative, as also are transfer and fare parameters, while air condition, Wi-Fi and reserved ladies' seats have positive coefficients. This means that respondents dislike walking and waiting for longer, as they also dislike travelling for longer, transferring more times, and paying more. On the other hand, they do like the presence of AC, Wi-Fi and reserved ladies' seats.

Table 3: Parameter values and main fit indices for models

		Islamabad		Lahore		Karachi	
		Estimate	t-ratio	Estimate	t-ratio	Estimate	t-ratio
Alternative	Do not travel			0.0000	(base)	0.0000	(base)
Specific	Van	-0.3480	-1.52	5.4827	12.64	5.0772	12.17
Constants	Mini-bus	-0.0648	-0.28	6.3515	21.73	5.3098	12.65
	Bus	-0.2059	-1.12	6.4624	23.52	4.8382	10.78
	Metro-bus	0.0000	(base)	6.9846	24.84		
	Qingqi	-	-	-	-	5.3468	12.50
	Car-pool	-0.0265	-0.12	6.3166	21.09	5.1105	12.29
	Orange line			6.8542	24.25		
Time	Access time (AT)	-0.0215	-6.94	-0.0461	-13.26	-0.0175	-3.57
	Waiting time (WT)	-0.0151	-5.15	-0.0604	-15.24	-0.0075	-2.71
	Van (TT)	-0.0336	-9.45	-0.0275	-4.63	-0.0064	-1.82
	Mini-bus (TT)	-0.0389	-10.68	-0.0402	-9.22	-0.0073	-2.08
	Bus(TT)	-0.0350	-11.69	-0.0348	-9.76	-0.0022	-0.50
	Metro-bus (TT)	-0.0363	-10.74	-0.0322	-10.11		
	Qingqi (TT)	-	-	-	-	-0.0261	-2.54
	Car-pool (TT)	-0.0372	-10.28	-0.0373	-6.50	-0.0084	-1.15
	Metro			-0.0412	-9.19		
Transfers		-0.2490	-10.38	-0.2509	-8.33	-0.2981	-8.46
Services	Air Cond.	0.8081	13.01	0.1375	2.11	0.1116	1.89
	Wifi	0.7192	12.19	0.0370	0.65	0.0816	1.23
Ladies' seats	Male	0.9007	11.58	0.0876	1.38	0.0987	1.25
	Female	1.5728	8.87	0.0768	0.75	0.1913	2.04
Fare		-0.0302	-8.84	-0.0444	-10.52	-0.0075	-4.39
Fit	Likelihood		-2252.7		-2874.0		-3263.0
	Number of individuals		530		515		520
	Number of observations		2120		2060		2080
	Number of parameters		17		20		18
	Rho2		0.3398		0.283		0.1245
	Adjusted Rho2		0.3348		0.278		0.1196

Even though all models across cities share the same formulation, they do not share the same scale, and therefore the magnitude of their parameters cannot be compared directly. Furthermore, in line with a custom in choice modelling literature, Willingness to pay (WTP) for a fare for each attribute is computed. The WTP represents the amount of money individuals are willing to exchange for an attribute. In the case of an undesirable attribute, it represents the monetary compensation the user requires for enduring that undesirable attribute, or alternatively, the reduction in price necessary to avoid a reduction in the probability of choosing that alternative. For example, in the case of travel time, the WTP for one minute of travel time represents the extra amount of money a user is willing to pay in the fare to reduce their travel time by one minute.

These values not only help the meaningful interpretation of the results, but they also facilitates the comparison of the results across the cities.

Willingness to pay (WTP) for each attribute is presented in Table 4. WTP are not calculated for the alternative specific constants, as their interpretation is complex and unclear. WTP estimates for all attributes in each city include a 95% confidence interval (CI) around the mean WTP value. If a CI crosses over zero it means that the WTP is not significantly different from zero.

WTP estimates show that the value of time for most uses is lower than the minimum wage (approximately 0.83 Rs/hour, assuming 45 work hours per week). This is in accordance with other studies in the value of travel time savings, where the estimated values for trips with multiple purposes were just below the minimum wage (Department for Transport 2015, Wardman et al. 2016).

Unlike most of the empirical evidence, the value of access (AT) and waiting time (WT) in Islamabad is smaller than the in-vehicle time (TT). This means that commuters place greater negative value on in-vehicle time. Most plausibly, this due to the relatively shorter trips in the Islamabad. Furthermore, data in Islamabad was collected during July and August 2021, matching a peak of Covid-19 cases in Pakistan[1]. As people might have been more scared of contracting Covid-19 during data collection in Islamabad, and hence they have penalised in-vehicle travel time more strongly due to increased probability of getting infected. However, data from Lahore and Karachi was collected later in the year, during a valley in the number of Covid-19 cases.

Higher in-vehicle values of time for a given mode indicate that individuals are willing to pay more to reduce the travel time in that mode. In other words, a high value of time could mean that passengers find that mode less comfortable and are therefore more willing to pay to reduce their time on it. Moreover, this also means that commuters of that mode are richer and are therefore more willing to pay to reduce their travel time in general.

The most onerous mode is mini-bus for commuters in Islamabad and Lahore. However, in Karachi, it is the Qingqi, which is followed by mini-bus. Qingqi, however, has a very large value of travel time, probably because this mode is used only for short trips. Furthermore, its confidence interval is very wide, pointing to the value being measured with little accuracy. Therefore, the value of travel time by Qingqi should be considered with caution. A similar situation happens with the value of access time in Karachi.

Transfers (changing from one vehicle to another of the same mode) are particularly onerous for Karachi residents. This is probably due to Karachi lacking a well-developed and interconnected public transport system in addition to already longer trips. As transport systems grow and are centrally planned, the number of transfers tends to increase because the transport systems are often structured around feeder and main (or “trunk”) services, making transfers more common. Less developed and organic transport systems tend to offer more point-to-point services that are less efficient, but require fewer transfers.

Air conditioning and Wi-Fi are more valued in Islamabad, followed by Karachi, and finally Lahore. The presence of reserved seats for women is only significantly valued in Islamabad, by both men

[1] https://ourworldindata.org/coronavirus/country/pakistan

and women, but with women valuing it 66% higher than men. It is not clear why commuters in Lahore and Karachi do not seem to value this service. One intriguing interpretation could be the less liberated and more conservative society of Islamabad due to their rural and tribal origins as compared to Lahore and Karachi which are more industrialised and old metropolitans.

Table 4: Willingness to pay with 95% confidence interval

		Islamabad			**Lahore**			**Karachi**		
		Lower	Mean	Upper	Lower	Mean	Upper	Lower	Mean	Upper
Time	Access	-27.0	-42.7	-58.4	-47.8	-62.3	-76.9	-38.5	-139.8	-241.2
(Rs/H)	Waiting	-16.5	-30.0	-43.4	-63.0	-81.6	-100.1	-7.8	-59.9	-112.1
	Van	-45.5	-66.9	-88.3	-20.4	-37.2	-54.1	6.5	-50.7	-108.0
	Mini-bus	-55.2	-77.4	-99.7	-38.6	-54.3	-70.0	4.8	-58.5	-121.9
	Bus	-50.7	-69.5	-88.3	-33.9	-47.0	-60.0	50.9	-17.5	-85.9
	Metro-bus	-50.9	-72.3	-93.7	-31.5	-43.5	-55.4			
	Qingqi							-6.6	-208.2	-409.8
	Car-pool	-51.9	-73.9	-95.9	-32.5	-50.4	-68.4	49.4	-67.4	-184.3
	Orange line				-39.8	-55.7	-71.5			
Transfers		-5.9	-8.3	-10.6	-4.0	-5.6	-7.3	-20.6	-39.7	-58.7
Services	Air Cond.	33.5	26.8	20.1	0.2	3.1	6.0	32.0	14.9	-2.2
	Wifi	30.2	23.8	17.5	3.3	0.8	-1.7	29.2	10.9	-7.5
Ladies' seats	Male	37.9	29.9	21.9	4.8	2.0	-0.8	34.2	13.1	-8.0
	Female	69.0	52.1	35.3	6.3	1.7	-2.8	52.7	25.5	-1.7

Finally, to identify the attributes with the biggest impact on the choice of a travel mode, **Error! Reference source not found.**4 presents the Average Marginal Effects (AME) of changes in attributes into the probability of choosing that alternative, as well as its 95% confidence interval. For example, keeping other things constant, increasing the access time of the Van by 10 minutes in Islamabad generates an average decrease of about 2% on the probability of choosing Van. This means that the further the van stop is from an individual's home, the less likely they are to use the van, and this probability will decay –on average- 2% per additional 10 minutes of walking.

In Islamabad we observe that the impact of access time is very similar across all modes. This is because all modes share the same coefficient, and the alternative specific constants are small and not significant in the model for this city. The same thing happens in the case of waiting time. However, as expected, the effect of an increase of in-vehicle time (TT) varies between modes, i.e. -3.16% for van and -3.90 for car-pool. On the other hand, this effect is always bigger than the effect of increasing access or waiting time. Increasing the number of transfers (from one vehicle to another vehicle for subsequent journey) by one has an equivalent effect on choice probabilities of mode as increasing access time by 10 minutes.

Reserved ladies' seats in a public transport mode is the attribute with a largest AME, especially among women. This is followed by the two on-board services, i.e. air conditioning and Wi-Fi. This means that amenities in public transport carry significant value for commuters in the studied Pakistani cities. Changes in access, waiting and travel times would have to be bigger than 10 minutes to surpass the effects of ladies' seats, air conditioning or Wi-Fi. But achieving travel time reductions bigger than 10 minutes in congested cities is not an easy task.

In Lahore we observe that access, waiting and travel time has different impact on different modes. This is so because, even though all modes have the same access and waiting time coefficient, their alternative specific constants are significantly different, leading to different results. For example, the probability of choosing Van in Lahore (5% on average across the whole sample) is much lower than choosing Metro-bus (25%), so even if the attributes of van change for the worst, their average effect cannot be very big, as the probability cannot decrease more than 5% before reaching 0%; on the other hand, the probability of Metro-bus has much more room to decrease.

Orange line and Metro-bus are the modes more negatively affected by increases in access and waiting time, meaning that commuters are discouraged to use those modes if they need to walk long distances to reach them, or have to wait for too long at bus stops or metro stations. Van, on the other hand, is the mode least affected by access and waiting times. This is possibly because Metro and Metro-bus modes are generally more efficient than van or mini-bus. The effect of travel time follows the same trend, but with a less onerous effect, indicating that waiting and access time are valued more negatively than in-vehicle time. This implies that reducing access and waiting time for public transport could increase commuters' welfare, and thereby incentivize and enhance their use of the public transport modes. On average, the effect of one additional transfer in a trip is slightly less onerous than a 10 minutes increase in travel time. This and the above finding together suggest that transfers are painful, but this discomfort could be reduced if the waiting and access time are lesser which could be achieved by designing the more comprehensive and inclusive routes and timeliness of the public transport.

On-board services have little to no effect on the mode choice among the commuters in Lahore as air conditioning is the only service which increases the probability of choosing a mode by nearly 1%. It is plausible to say that commuters in Lahore already have these amenities in Metro-bus and Orang-line, hence they place a less value on these.

The impact of access, waiting and travel time in mode decisions for commuters in Karachi is much lower than in Lahore, and more similar to the Islamabad (except for travel time). While increasing access time by 10 minutes has an average effect across modes in Karachi of -2.6%, the same value reaches -4.4% in Lahore, and -2.2% in Islamabad. Results are similar for waiting time. The effect of travel time, on the other hand, is significantly lower in Karachi (average -1.4%) as compared to both Islamabad (-3.7%) and Lahore (-3.6%). The obvious interpretation of this is that Karachi has very limited public transport options, hence commuters pay less attention to the travel time as their first priority is to have a public transport mode. Furthermore, it is a big city and travel is usually more time consuming in most of the modes, including private taxi, resulting commuters' lack of attention or to the longer travel times.

As discussed before, transfers have a significantly greater effect on commuters in Karachi than those in Islamabad and Lahore. This suggests that transfers are more painful in Karachi, and hence contribute to commuters' disutility from public transport. This however is expected in Karachi as the city has very poor public transport system and changing the mode within a journey could be very annoying and time consuming. This finding spells out a clear policy implication: that transfers should be made easy and less time consuming for commuters in Karachi so that their transits are less painful. This could be achieved by efficient rout designing and a better coverage of the main areas of the city.

Finally, concerning on-board services in Karachi, the only service that has a significant impact on commuters' choice is the presence of reserved ladies' seats in metro-bus and qingqi among women.

Table 5: Average Marginal Effects (AME) of attributes on the probability of choosing each mode (%)

		Islamabad			**Lahore**			**Karachi**		
		Lower	Mean	Upper	Lower	Mean	Upper	Lower	Mean	Upper
Access time	Van	-2.51	-2.02	-1.42	-1.94	-1.53	-1.24	-4.17	-2.84	-1.15
(+10 min)	Mini-bus	-2.73	-2.20	-1.50	-4.14	-3.53	-2.91	-4.75	-3.07	-1.25
	Bus	-2.85	-2.23	-1.55	-5.16	-4.50	-3.74	-3.82	-2.54	-1.01
	Metro-bus	-2.86	-2.29	-1.58	-7.02	-6.06	-5.17	-2.86	-1.87	-0.77
	Qingqi							-3.74	-2.55	-1.00
	Car-pool	-2.92	-2.31	-1.60	-5.14	-4.51	-3.77			
	Orange line				-7.09	-6.15	-5.12			
Waiting	Van	-2.04	-1.46	-0.96	-2.41	-1.94	-1.54	-2.14	-1.27	-0.46
Time	Mini-bus	-2.17	-1.59	-1.06	-5.04	-4.52	-3.96	-2.30	-1.37	-0.50
(+10 min)	Bus	-2.22	-1.60	-1.09	-6.51	-5.81	-5.21	-1.92	-1.13	-0.41
	Metro-bus	-2.22	-1.64	-1.10	-8.53	-7.88	-7.09	-1.42	-0.84	-0.29
	Qingqi							-1.89	-1.14	-0.41
	Car-pool	-2.30	-1.66	-1.13	-6.50	-5.79	-4.98			
	Orange line				-8.81	-7.99	-7.14			
Travel	Van	-3.66	-3.16	-2.60	-1.47	-0.98	-0.60	-2.03	-1.18	-0.02
Time	Mini-bus	-4.42	-3.88	-3.40	-3.68	-3.20	-2.56	-2.56	-1.37	-0.21
(+10 min)	Bus	-4.01	-3.58	-3.13	-4.03	-3.49	-2.89	-1.59	-0.34	0.91
	Metro-bus	-4.28	-3.87	-3.35	-5.07	-4.41	-3.53	-4.48	-2.69	-0.36
	Qingqi							-3.19	-1.25	0.65
	Car-pool	-4.48	-3.90	-3.26	-4.95	-3.83	-2.82			
	Orange line				-6.89	-5.70	-4.58			
Transfers	Van	-2.80	-2.37	-1.97	-1.27	-0.91	-0.64	-5.71	-4.65	-3.45
(+1)	Mini-bus	-3.01	-2.59	-2.14	-2.50	-2.03	-1.46	-6.15	-5.01	-3.78
	Bus	-3.10	-2.61	-2.16	-3.24	-2.57	-1.88	-4.97	-4.12	-3.08
	Metro-bus	-3.16	-2.69	-2.29	-4.22	-3.41	-2.61	-3.71	-3.02	-2.25
	Qingqi							-5.13	-4.14	-2.99
	Car-pool	-3.20	-2.72	-2.25	-3.38	-2.60	-1.85			
	Orange line				-4.22	-3.47	-2.52			
Air	Van	3.55	4.31	5.23	0.01	0.28	0.58	-0.01	0.64	1.23
Conditioning	Mini-bus	3.25	3.96	4.64	0.02	0.60	1.16	-0.02	1.00	1.93
	Bus	3.98	4.66	5.42	0.03	0.69	1.38	-0.01	0.59	1.17
	Metro-bus	3.12	3.77	4.35	0.04	0.89	1.74	-0.02	1.27	2.52
	Qingqi							-0.01	0.61	1.17
	Car-pool	3.54	4.18	4.87	0.03	0.85	1.72			
	Orange line				0.00	0.00	0.00			
Wifi	Van	3.07	3.71	4.25	-0.13	0.06	0.25	-0.51	0.86	2.48
	Mini-bus	2.77	3.38	3.86	-0.28	0.13	0.56	-0.51	0.94	2.82
	Bus	3.20	3.77	4.32	-0.34	0.16	0.64	-0.36	0.65	1.89
	Metro-bus	3.22	3.78	4.27	-0.41	0.19	0.79	-0.51	0.94	2.62
	Qingqi							-0.73	1.25	3.70
	Car-pool	3.45	4.14	5.00	-0.38	0.18	0.75			
	Orange line				-0.41	0.19	0.76			
Ladies' seats	Van	3.97	4.50	5.40	-0.09	0.19	0.57	-0.76	0.43	1.98

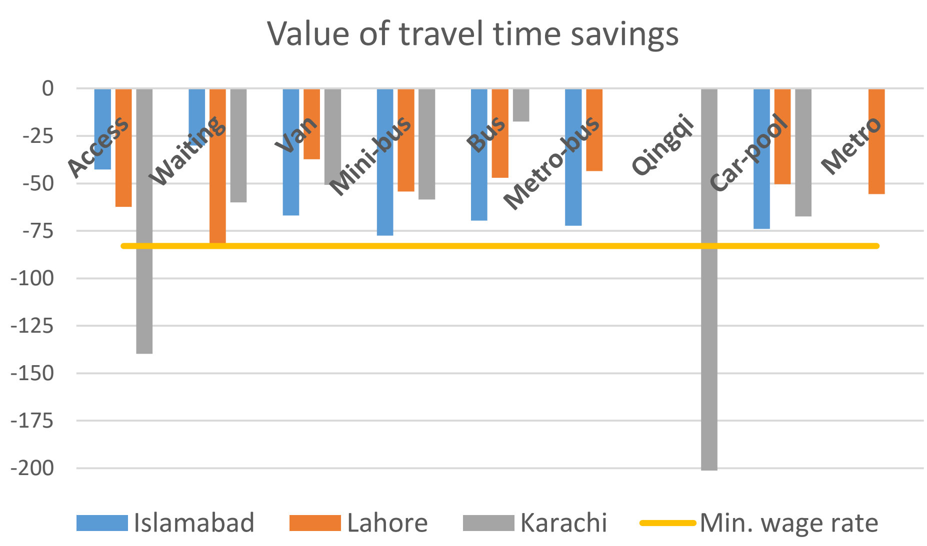
	Mini-bus	4.04	4.64	5.51	-0.17	0.36	0.99	-0.96	0.35	1.97
(male)	Bus	4.57	5.27	6.10	-0.22	0.48	1.34	-0.57	0.71	2.29
	Metro-bus	3.91	4.49	5.23	-0.29	0.57	1.67	-0.11	1.34	3.31
	Qingqi							-0.14	1.80	4.09
	Car-pool	4.83	5.64	6.56	-0.25	0.47	1.31			
	Orange line				-0.28	0.67	1.94			
Ladies' seats	Van	6.02	7.44	8.80	-0.25	0.19	0.63	-0.17	1.74	3.55
	Mini-bus	6.42	7.73	8.90	-0.52	0.36	1.22	-0.21	1.80	3.89
(female)	Bus	6.93	8.38	9.77	-0.76	0.48	1.65	-0.02	1.84	3.64
	Metro-bus	6.24	7.67	8.92	-0.87	0.58	1.95	0.14	2.07	3.84
	Qingqi							0.16	2.73	4.98
	Car-pool	6.96	8.51	9.76	-0.76	0.48	1.56			
	Orange line				-0.93	0.68	2.21			

4.3 Conclusions and Policy Implications

This study reveals meaningful results and interesting insights concerning commuters' preferences in Islamabad, Lahore, and Karachi. Findings from Islamabad and Lahore are more intuitive than those from Karachi. This is somewhat expected considering the greater heterogeneity in socioeconomic, cultural, ethnic, and geographical aspects; in addition to extremely inefficient and thin public transport infrastructure in the city could contribute to a more heterogeneous and less focused response from travellers in Karachi. This is most likely due to similarities in socioeconomic and cultural factors, and improved public transport system in Islamabad and Lahore. For example, the transport modes offered as alternatives are similar and relatively better in these cities as compared to Karachi.

All time parameters (*access*, *waiting*, and *travel time*), *transfers*, and *fare* are negative across three models from the three datasets, just as expected due to these being undesirable attributes. On the other hand, *air conditioning*, *Wi-Fi* and *reserved ladies' seats* are desirable attributes and have positive parameters in the datasets from all three cities, though not all of them reach significance in all cities. This implies that, in general, availability and access to public transport are considered more crucial than the other amenities, which makes theoretical sense.

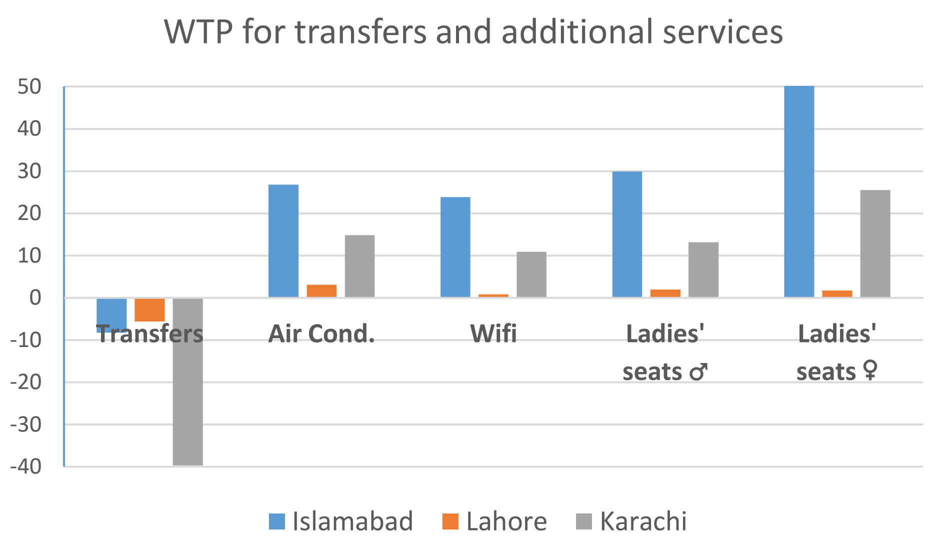
Figure 1: Summary of WTP for access, waiting and travel time



Willingness to Pay (WTP) estimates, summarised in **Error! Reference source not found.**, show that most commuters value their time in less than the minimum wage rate of 83 Rs/hour (assuming 45 work hours per week). This is in line with the other studies, where the estimated value of travel-time-savings for trips with multiple purposes were just below the minimum wage (Department for Transport 2015, Wardman et al. 2016). Furthermore, the value of access and waiting time in Islamabad is smaller than the in-vehicle time, indicating that commuters in Islamabad place greater negative value on in-vehicle time. This could be due to the relatively shorter trips in Islamabad, as they are not used to with longer trips. It could also relate to the data being collected during a time coinciding with a peak of active Covid-19 cases in Pakistan. The fear of getting infected may have caused individuals to more strongly dislike the in-vehicle travel time due to a higher chance of getting infected (which matches the results, as WTP for in-vehicle time is higher in Islamabad than in other cities). By contrast, travellers' dislike for walking and waiting might have decreased, as the chances of being infected during those times was lower.

Mini-bus is the mode with higher WTP for in-vehicle time reduction in Islamabad and Lahore, and the third highest in Karachi (surpassed only by *qingqi* and *car-pool*). This points to Mini-bus being one of the least preferred modes, because travellers are willing to pay more to reduce their time on it. The situation for *qingqi* is somewhat different, as its high value of in-vehicle travel time can be explained because this mode is only used for relatively short trips (i.e. the "last mile" or "last leg" of a trip), and therefore users would require a big fare discount to be willing to make longer trips in the mode.

Figure 2: Willingness to pay for transfers and additional services

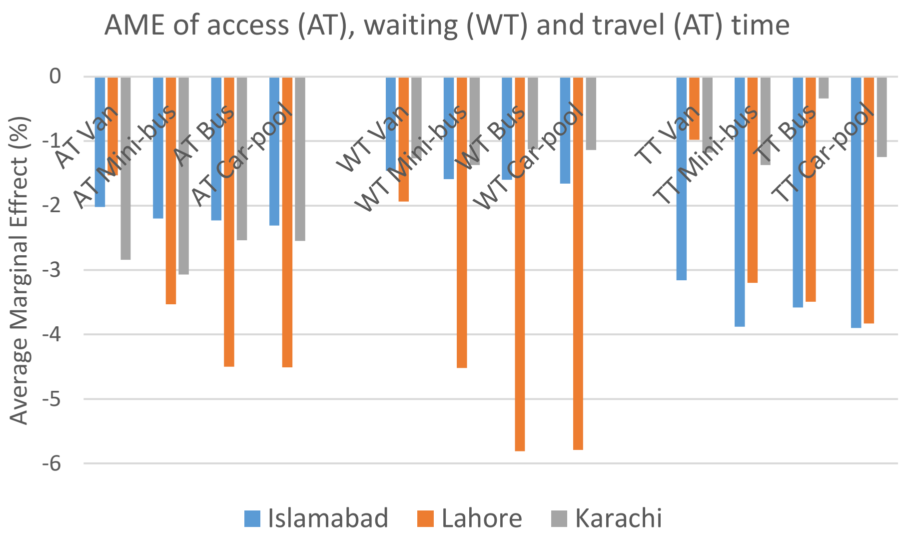


Concerning *car-pool*, Lahore displays the lowest WTP for in-vehicle travel time reduction, at a similar level to *buses*' WTP. This makes Lahore the most promising city to implement a wide *car-pool* system. The fare could be higher to the bus, as this mode would imply a reduced access and waiting time, as well as a reduced number of transfers. The fare could be further increased for cars with air conditioning.

Access time and transfers are highly disliked by travellers in Karachi, with a WTP of -140 Rs/hour for the first, and -40 Rs/transfer for the second. This is probably due to Karachi lacking a well-developed and interconnected public transport system, in addition to already longer trips. Today, travellers in Karachi are likely to make long trips in a single vehicle. While comfortable for the user, this is inefficient from a system perspective. Throughout the world, centrally organised and efficient public transport systems work with a trunk and feeder system, where small buses take travellers from residential areas to the city's main roads, where the travellers transfer to bigger buses that take them to the main centres of activities. Travellers in Karachi are likely to oppose such a structure, so if such a model is to be implemented, it should be introduced in phases to reduce travellers' opposition to it.

Results indicate that the presence of reserved seats for women is only significantly valued in Islamabad, by both men and women, but with women valuing it 66% higher than men. The average valuation of all additional services in Lahore is low, with air conditioning being the only additional service reaching a valuation significantly different to zero at only 3 Rs. The lack of a significant valuation of reserved seats for women might be due to a higher perception of safety in Lahore as compared to the other cities. Valuation in Karachi, on the other hand, is much higher than in Karachi, but also more heterogeneous, so none of the additional services (AC, Wi-Fi, reserved ladies' seats) reach a valuation significantly different from zero. There could be, however, segments of users that would value these services.

Figure 3: Average Marginal Effects of a 10 minutes increase in access, waiting and travel time across common modes present in all cities

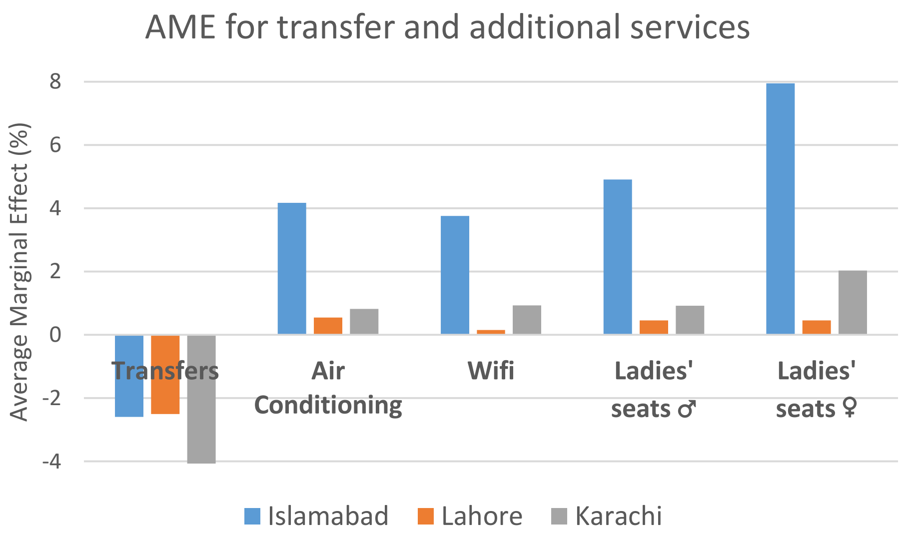


The Average Marginal Effects (AME) allow for easy identification of the attributes that most strongly influence the decision of what transport mode to use. A summary of them are presented in **Error! Reference source not found.** and . In them, it is very evident that access and waiting times are much more important for travellers in Lahore than in Islamabad and Karachi. This is what is normally observed in cities with a developed transport system. On the other hand, the impact of access, waiting and travel time in mode decisions for travellers in Karachi is much lower, suggesting that they place less value in time parameters, as their first priority is to have a working public transport mode. Furthermore, Van is the mode least sensitive to changes in travel time in all three cities, except for Bus in Karachi.

As discussed before, transfers have a significantly greater effect on commuters in Karachi than those in Islamabad and Lahore (), meaning that transfers are more painful in Karachi. This is expected in Karachi as the city has very poor public transport system and changing the mode within a journey could be very annoying and time consuming. This finding spells out a clear policy implication: that transfers should be made easy and less time consuming for commuters in Karachi so that their transits are less painful. This could be achieved by efficient route designing and a better coverage of the main areas of the city.

The largest AME is due to the presence of reserved ladies' seats in Islamabad, which increases the probability of choosing a mode by 6% on average. This is a relatively easy change to implement, so it is highly recommended to implement it in Islamabad. Some users in Karachi might also value this service, though its effect would be lower, leading to only an expected 2% increase in the probability to use the mode. On-board services have little to no effect on the mode choice among travellers in Lahore, i.e. they place a less value on them. This is possibly because they already have these amenities in Metro-bus and Orange-line.

Figure 4: Average Marginal Effects of transfers and additional services



Findings (not shown in **Error! Reference source not found.**, but present in **Error! Reference source not found.**) also reveal that Metro and Metro-bus in Lahore are more negatively affected by increases in access and waiting time. This means that commuters are discouraged to use these modes if they need to walk long distances to reach them, or have to wait for too long at bus stops or metro stations. Van, on the other hand, is the mode least affected by access and waiting times. This means commuters expect Metro and Metro-bus to be more efficient than van or mini-bus. The effect of travel time follows the same trend, but with a less onerous effect, indicating that waiting and access time are valued more negatively than in-vehicle time. This implies that reducing access and waiting time for public transport could increase commuters' welfare, and thereby incentivize and enhance their use of the public transport modes. On average, the effect of one additional transfer in a trip is slightly less onerous than a 10 minutes increase in travel time. This and the above finding together suggest that transfers are painful, but this discomfort could be reduced if the waiting and access time are lesser which could be achieved by designing the more comprehensive and inclusive routes and timeliness of the public transport.

In summary, key results indicate that:

i. Karachi is in need of a better public transport system. Travellers are currently used to long trips. But implementing a better system would not be easy, as it would probably imply more complex trips with multiple transfers, something that travellers dislike in Karachi. Therefore, the new system should focus on reduced access and waiting times, as well as providing reserved ladies' seats if possible.
ii. Results from Lahore show a behaviour typical from big cities with a more developed transport system, where access and waiting time are more onerous than in-vehicle travel time. Car pool systems could be implemented in the city to reduce the use of car, as this city is the one that is most likely to adopt such a system.
iii. Islamabad displays the biggest sensitivity to the provision of additional services while travelling. Adding air conditioning, Wi-Fi, and especially reserved ladies' seats in public transport could have a significant impact in increasing its use in this city.

APPENDICES

Appendix – I

Background information (Islamabad)

1. What are the existing modes of transport in ***the three selected cities***? For example, in Islamabad, these are van, minibus and metro mainly. But there might be other in the documents.

Islamabad: Wagon (80%), Minibus (5%), Metro Bus (10%), Suzuki pickup (3%) Qinchi (<1%)

2. For ***each mode in each city***:

a. Is it public or privately funded?

Metro bus is Public Funded & all other modes are privately funded

b. Does it have pre-defined routes? If so, who sets the routes (transport department or private operator)?

Yes, Routes are pre-defined and it is set by Regional Transport departments e.g. (Islamabad Transport Authority issues the permit for routes)

c. What is their market share? Market competition for share and incentive to compete or other relevant information.

Market share for the privately funded transport is more than 80%.

d. What is the fare system? Is it a flat fare per trip or does it change by distance? Is there a special fare for students or the elderly?

Fare system is distance based and provincial Transport Authority (Mainly secretary Public Transport in every Provinces) sets it. For Punjab (Includes Lahore and Islamabad), the fare varies after

e. What is their average fare per kilometer? The answer to this question must have a lot of information beyond fare and it is very crucial to collect all of this from relevant departments.

Mode	**Distance (Km)**	**Fare (PKR)**
Van & Minibus	4	15
	8	20
	14	24
	22	28
	30	35
Metro Bus	No dependence (Track length is 22.5 Km)	30
Suzuki Pickup	4	12
	8	16
	12	20
	16	24
Qinchi	It is used as taxi and there is no fixed fare per km distance (usually bargain fare b/w commuter and Qinchi driver)	

For example, there might be some subsidy in case of Metrobus or there is difference in set fare and market fare (which is actually paid by commuters). Similarly, information on how the fare is regulated is also very important.

Mode	**Subsidies**
Van	No
Minibus	No
Metro	1.9 Billion RS/ Year
Suzuki Pickup	N0
Qinqchi	NO

3. What is the average access time in minutes (includes walking time at beginning and end of trip) for each mode of public transport? Knowing an approximate variation range (min and max) would also be useful.

Mode	**Average Access Time Islamabad (from commuters of Bharakahu, F8 Kachahri (metro) and Aabpara wagon station)**
Van	15 mins
Minibus	20 mins
Metro	10 mins
Suzuki Pickup	15 mins

4. What is the average waiting time (at stop) and travel time in minutes for each mode of public transport? For example, average travel time for a trip for each mode of public transport in each city. Knowing an approximate variation range (min and max) would also be useful.

I have collected information from Islamabad commuters on three spots (from commuters of Bharakahu, F8 Kachahri (metro) and Aabpara wagon station) regarding their waiting and travel times and average times are below:

Mode	**Waiting Time (Peak)**	**Waiting Time (off-Peak)**	**Travel Time (Peak)**	**Travel Time (off-Peak)**
Minibus	20 mins	15 mins	30-35 mins	25-30 mins
Wagon	15 mins	10 mins	Upto 60 mins	30-45 mins
Metrobus	5-7 mins	10 mins	Around 50 mins	Around 50 mins
Suzuki Pickup	15 mins	12 mins	40 mins	30 mins
Qinchi	N/A	N/A	N/A	N/A

What is the average number of transfers for a trip for each mode of public transport in each city? This could be different for different modes of public transport as well as across the center (CBD) and periphery areas. Knowing an approximate variation range (min and max) would also be useful.

1) Transfers within the same mode **(in overall survey (0/12) commuters transfer to same mode**
2) Transfers across the different modes **(2/12) but Metro commuters do that live away from Saddar or approaching metro station from aabpara they use wagons and their dominant mode was metro bus). Moreover, their average number of transfer is 1.**

What is the coverage of each mode of public transport in each city? There will be a lot of information around this question as coverage is a serious problem in Pakistani public transport.

In the case of Islamabad according to ITA

Mode	**Coverage (%)**
Wagons	80
Minibus	5
Metro	10
Suzuki Pickup	3
Qinchi	<1

How female friendly are existing modes of public transport? What have been done in this regard? For example, there was some discussion on ***Pink Buses***.

Which mode are more or less comfortable for females?

Female security and comfort as security and comfort is more subjective as different people define 'what is safe and secure?' and 'what is comfortable?' differently.

Mode	**Teasing**	**Staring**	**Touching**	**Groping**	**Reserve seats**	**Door to door access**
Wagon	Very few	Quiet often	Rarely	Few	Front two	No
Minibus	Rarely	Quiet often	Rarely	Yes	No	No
Metro bus	Rarely	Very few	No	Yes	Yes	Yes
Suzuki Pickup	Rarely	Quiet often	Quiet often	Yes	No	No
Qinchi	N/A	N/A	N/A	N/A	N/A	N/A

Gather as much information as you can around ***AC and Wifi*** in public transport. Urgency, benefits, incentive etc.

Mode	**AC**	**WIfi**
Wagons	NO	NO
Minibus	NO	NO
Metro bus	Yes	NO
Suzuki Pickup	No	NO
Qinchi	No	No

a. Service providers: individual transporters, private companies, government.

More than 80% are individual Transporters in the case of Islamabad. While Metrobus service is government funded.

b. Conduct and professionalism of the staff/service quality (bad, fair, good) (information from commuters)

Mode	**Behavior of Conductor/ Employees**
Wagons	(3/5) Bad and (2/5) Fair
Minbus	(4/5) bad
Metrobus	(3/3) (good)
Suzuki Pickup	(2/3) bad
Qinchi	It is not used in these areas but in order to keep uniform design of the study we keep it here as per instructions.

5. Origin-destination information. Transport departments may have information on number of trips from and to different areas of the city during the morning peak or other times. This is usually expressed as matrices, for example:

Origin \ Destination	**City centre**	**Neighbourhood 1**	**Neighbourhood 2**
City centre	100	50	50
Neighbourhood 1	500	80	150
Neighbourhood 2	800	200	300

a. If available, we need to get this information, including the definition of each area (e.g. what exactly does "City centre" means).

The city center in the case of Islamabad is consider as the Blue Area (commercial hub).

b. They may have similar matrices for other data, for example the average travel time by origin-destination pair, or the average fare for a given mode, etc.

This data is unavailable with the secondary sources.

After collecting all possible information from secondary sources, you should validate it against data provided by commuters. The idea is to ask a small sample of commuters about their trips, record their answers, and later compare them to the information gathered from the authorities. Does it match? The things to ask commuters:

- Origin and destination of trip

The origin and destination varied for each commuter surveyed. For example, the metro bus trip originated from F-8 Kachahri stop ended in saddar metro-bus stop (destination).

- Description of the trip: how many legs? Mode, fare, access, waiting and travel time of each leg.

(10/12) commuters are using single mode.

- Purpose of the trip

(11/12) were doing work trip (going to offices and jobs).

- How often the trip is made

5 Days a week.

- What other alternative ways to travel the person could have used? Not very interested in other possible routes using the same modes, but on other modes that could be used, e.g. driving and taking a taxi instead of public transport, or the metro instead of the bus.

Taxi/Uber and Careem are alternative options.

A lot of this and other relevant information is available in ***origin – destination surveys*** which you will have to access and acquire. Also, provincial governments (especially Punjab government) have their master plans and datasets on transport.

Background information (Lahore)

What are the existing modes of transport in ***the three selected cities***? For example, in Islamabad, these are van, minibus and metro mainly. But there might be other in the documents.

Lahore: wagon (30%), Buses (metro, Feeder by LTC & speedo) (40%), orange Metro Train system (10%), Qingqi (15%), Suzuki pickup (<1%)

For ***each mode in each city***:

c. Is it public or privately funded?

   Metro bus, feeder buses, speedo and orange Metro train system are Public Funded & all other modes are privately funded

d. Does it have pre-defined routes? If so, who sets the routes (transport department or private operator)?

   Yes, Routes are pre-defined and it is set by Regional Transport departments e.g. (Punjab Mass transit Authority (PMTA) & Lahore Transport Company (LTC))

e. What is their market share? Market competition for share and incentive to compete or other relevant information.

   Market share for the privately funded transport is around 50% in Lahore according to official source of PMTA.

f. What is the fare system? Is it a flat fare per trip or does it change by distance? Is there a special fare for students or the elderly?

   Fare system is distance based and provincial Transport Authority (Mainly secretary Public Transport in every Provinces) sets it.

g. What is their average fare per kilometer? The answer to this question must have a lot of information beyond fare and it is very crucial to collect all of this from relevant departments.

Mode	Distance (Km)	Fare (PKR)
Wagons	4	15
	8	20
	14	24
	22	28
	30	35
Metro Bus	No dependence (Track length is 27Km)	30
Speedo	25 RS up to metro station and then charge 10 RS on metro	25
	4	20

Feeder Buses (LTC)	8	25
	14	30
	22	35
	38	40
Orange Metro Line	No dependence (Track length is 27Km)	40
Qinchi (taxi)	It is used as taxi and there is no fixed fare per km distance (usually bargain fare b/w commuter and Qinchi driver)	
Qingi (Share ride)	1-4	20
	4-8	25
	8-12	30
	12-15	40
Suzuki Pickup	It is not used in Lahore but in order to keep uniform design of the study we keep it here as per instructions.	

For example, there might be some subsidy in case of Metrobus or there is difference in set fare and market fare (which is actually paid by commuters). Similarly, information on how the fare is regulated is also very important.

6. **Mode**	**Subsidies**
Wagon	No
Metro Bus	Rs 1.9 Billion
Feeder Buses (pink buses and Speedo)	Rs 4.25 billion
Orange Metro Line	Rs 4.5 billion
Qinchi	NO
Suzuki Pickup	NO

Sources: https://www.dawn.com/news/1614258

a. What is the average access time in minutes (includes walking time at beginning and end of trip) for each mode of public transport? Knowing an approximate variation range (min and max) would also be useful.

Mode	**Average Access Time Lahore (Mazang, Chuburji & Johar town)**
Wagon	10 mins
Metro bus	10 mins
Feeder buses	10 mins
Speedo	15 mins
Orange Metro Line	10 mins
Qingqi	5 mins
Suzuki Pickup	It is not used in these areas but in order to keep uniform design of the study we keep it here as per instructions.

What is the average waiting time (at stop) and travel time in minutes for each mode of public transport? For example, average travel time for a trip for each mode of public transport in each city. Knowing an approximate variation range (min and max) would also be useful.

I have collected information from Lahore 15 commuters on three spots (Mazang, Chuburji & Johar town) regarding their waiting and travel times and average times are below:

Mode	**Waiting Time (Peak)**	**Waiting Time (off-Peak)**	**Travel Time (Peak)**	**Travel Time (off-Peak)**
Minibus	20 mins	15 mins	30-35 mins	25-30 mins
Wagon	15 mins	10 mins	Upto 60 mins	30-45 mins
Metrobus	5-7 mins	10 mins	Around 50 mins	Around 50 mins
Metro train	10 mins	10 mins	45 mins	45 mins
Speedo	10 mins	5-7 mins	35 mins	25 mins
Feeder Buses	5 mins	10 mins	75 mins	60 mins
Qingqi	5 mins	10 mins	30 mins	20 mins

b. What is the average number of transfers for a trip for each mode of public transport in each city? This could be different for different modes of public transport as well as across the center (CBD) and periphery areas. Knowing an approximate variation range (min and max) would also be useful.

3) Transfers within the same mode **(in overall survey (3/15) commuters transfer to same mode and dominant mode in the journey was bus) and average number of transfers are 1.**

4) Transfers across the different modes **(2/15) yes especially for the areas like mazang which is hub for transportation Metro commuters do shift to metro orange line train) in this case dominant mode is (Metro train) and average number of transfers are 1.**

5) **. In the areas away from the churbarji commuters use the qinchi after using metro bus (2/15), in this case dominant mode is (Metro bus) and average number of transfers are 1.**

   c. What is the coverage of each mode of public transport in each city? There will be a lot of information around this question as coverage is a serious problem in Pakistani public transport.

Mode	**Coverage (%)**
Wagons	30
Speedo	5
Metro bus	10
Metro train	10
Feeder Buses	20
Qingi	15
Sukuzi Pickup	<1

   d. How female friendly are existing modes of public transport? What have been done in this regard? For example, there was some discussion on ***Pink Buses***.

Which mode are more or less comfortable for females?

Female security and comfort as security and comfort is more subjective as different people define 'what is safe and secure?' and 'what is comfortable?' differently.

Mode	Teasing	Staring	Touching	Groping	Reserve seats	Door to door access
Wagon	Very few	Quiet often	Rarely	Few	Front two	No
Metro bus	Rarely	Very few	No	Yes	Yes	Yes
Speedo	Rarely	Very few	No	Yes	Yes	Yes
Metro train	Rarely	Very few	No	Yes	Yes	Yes
Feeder Buses	Rarely	Very few	No	Yes	Yes	Yes
Qingi	Rarely	Quiet often	Rarely	Yes	No	No
Suzuki Pickup	N/A	N/A	N/A	N/A	N/A	N/A

e. Gather as much information as you can around ***AC and Wifi*** in public transport. Urgency, benefits, incentive etc.

Mode	AC	WIfi
Wagons	NO	NO
Speedo	Yes	NO
Metro bus	Yes	NO
Metro train	Yes	NO
Feeder Buses	Yes	NO
Qingi	NO	NO
Suzuki Pickup	NO	NO

f. Service providers: individual transporters, private companies, government.

Mode	**Regulating Authority**
Wagons	Privately funded
Speedo	Public Funded (PMTA)
Metro bus	Public Funded (PMTA)
Metro train	Public Funded (PMTA)
Feeder Buses	Public Funded by (LTC)
Qingi	Privately funded

g. Conduct and professionalism of the staff/service quality (bad, fair, good) (information from 15 commuters in the areas of mazang, chuburji & Johar town)

Mode	**Behavior of Conductor/ Employees**
Wagons	(10/15) Bad and (4/15) Fair (1/15) good.
Speedo	(11/15) good (4/15) Fair
Metrobus	(10/15) good (3/15) Fair (2/15) Bad
Metro train	(12/15) good (3/15) Fair
Feeder Buses	(9/15) good (4/15) Fair (2/15) Bad
Qingi	Bad (12/15) and (3/15) Fair
Suzuki Pickup	It is not used in these areas but in order to keep uniform design of the study we keep it here as per instructions.

Origin-destination information. Transport departments may have information on number of trips from and to different areas of the city during the morning peak or other times. This is usually expressed as matrices, for example:

Origin \ Destination	**City centre**	**Neighbourhood 1**	**Neighbourhood 2**
City centre	100	50	50
Neighbourhood 1	500	80	150
Neighbourhood 2	800	200	300

h. If available, we need to get this information, including the definition of each area (e.g. what exactly does “City centre” means).

City center means the hub of commercial area.

i. They may have similar matrices for other data, for example the average travel time by origin-destination pair, or the average fare for a given mode, etc.

This data is unavailable with the secondary sources.

After collecting all possible information from secondary sources, you should validate it against data provided by commuters. The idea is to ask a small sample of commuters about their trips, record their answers, and later compare them to the information gathered from the authorities. Does it match? The things to ask commuters:

- Origin and destination of trip

The origin and destination varied for each commuter surveyed. For example, most of the metro bus trip originated from MAzang stop ended in Gajumata metro-bus stop (destination). Similarly, the most of the orange line commuters from trip originated from Churbhji ends at Dera Gujran.

- Description of the trip: how many legs? Mode, fare, access, waiting and travel time of each leg.

There is mix of one and two mode in the case of Lahore mostly, in our survey from commuters (8/15) used single mode (7/15) uses more than one mode.

- Purpose of the trip

(14/15) were doing work trip (going to offices and jobs).

- How often the trip is made

5 Days a week.

- What other alternative ways to travel the person could have used? Not very interested in other possible routes using the same modes, but on other modes that could be used, e.g. driving and taking a taxi instead of public transport, or the metro instead of the bus.

Taxi/Uber and Careem are alternative options.

A lot of this and other relevant information is available in ***origin – destination surveys*** which you will have to access and acquire. Also, provincial governments (especially Punjab government) have their master plans and datasets on transport.

Background information (KARACHI)

What are the existing modes of transport in ***the three selected cities***? For example, in Islamabad, these are van, minibus and metro mainly. But there might be other in the documents.

Karachi: Minibus & buses (75-80%), Qingqi (20-25%).

For ***each mode in each city***:

j. Is it public or privately funded?

   All modes are privately funded.

k. Does it have pre-defined routes? If so, who sets the routes (transport department or private operator)?

   Yes, Routes are pre-defined and it is set by Sindh Transport Authority.

l. What is their market share? Market competition for share and incentive to compete or other relevant information.

   Market share for the privately funded transport is 100% in Karachi.

m. What is the fare system? Is it a flat fare per trip or does it change by distance? Is there a special fare for students or the elderly?

   Fare system is distance based and provincial Transport Authority (Mainly secretary Public Transport in every Provinces) sets it.

n. What is their average fare per kilometer? The answer to this question must have a lot of information beyond fare and it is very crucial to collect all of this from relevant departments.

Mode	Distance (Km)	Fare (PKR)
Mini-buses	5	15
	10	20
	15	23
	20	30
	30	35
Qingi (booking)	5-15	100-150
Qingi (share ride)	1-4	20
	4-8	25
	8-12	30
	12-15	40

For example, there might be some subsidy in case of Metrobus or there is difference in set fare and market fare (which is actually paid by commuters). Similarly, information on how the fare is regulated is also very important.

There is no subsides public transport mode available in Karachi

o. What is the average access time in minutes (includes walking time at beginning and end of trip) for each mode of public transport? Knowing an approximate variation range (min and max) would also be useful.

Mode	**Average Access Time KARACHI (from the commuters North nazimabad, Baldia and Liari)**
Minibus	15-20 mins
Qingqi	5-10 mins

p. What is the average waiting time (at stop) and travel time in minutes for each mode of public transport? For example, average travel time for a trip for each mode of public transport in each city. Knowing an approximate variation range (min and max) would also be useful.

I have collected information from Karachi commuters on three spots (from 15 commuters from the areas of north nazimabad, baldiya and liyari) regarding their waiting and travel times and average times are below:

Mode	**Waiting Time (Peak)**	**Waiting Time (off-Peak)**	**Travel Time (Peak)**	**Travel Time (off-Peak)**
Minibus & Bus	20 mins	30 mins	60-70 mins	40-60 mins
Qingqi	5 mins	15 mins	50 mins	40 mins

q. What is the average number of transfers for a trip for each mode of public transport in each city? This could be different for different modes of public transport as well as across the center (CBD) and periphery areas. Knowing an approximate variation range (min and max) would also be useful.

6) Transfers within the same mode **(4/15) use Minibuses and dominant mode is minibus. Moreover, their average number of transfer is 1.**

7) Transfers across the different modes **(3/15) use Qinchi for last mile travel in after using minibus) dominant mode is minibus. Moreover, their average number of transfer is 1.**

r. What is the coverage of each mode of public transport in each city? There will be a lot of information around this question as coverage is a serious problem in Pakistani public transport.

Mode	**Coverage (%)**
Minibuses & Buses	75-80
Qingi	15-20

s. How female friendly are existing modes of public transport? What have been done in this regard? For example, there was some discussion on ***Pink Buses***.

Which mode are more or less comfortable for females?

Female security and comfort as security and comfort is more subjective as different people define 'what is safe and secure?' and 'what is comfortable?' differently.

Mode	**Teasing**	**Staring**	**Touching**	**Groping**	**Reserve seats**	**Door to door access**
Minibus	Rarely	Quiet often	Rarely	Yes	No	No
Qingi	Rarely	Quiet often	Rarely	Yes	No	No

t. Gather as much information as you can around ***AC and Wifi*** in public transport. Urgency, benefits, incentive etc.

Mode	**AC**	**WIfi**
Minibus	NO	NO
Qingi	NO	NO

u. Service providers: individual transporters, private companies, government.

Mode	**Funding**
Minibus	Privately funded
Qingi	Privately funded

v. Conduct and professionalism of the staff/service quality (bad, fair, good) (information from commuters)

Mode	**Behavior of Conductor/ Employees**
Minbus	(13/15) Bad and (2/15) Fair
Qingi	(10/15) Bad and (5/15) Fair

Origin-destination information. Transport departments may have information on number of trips from and to different areas of the city during the morning peak or other times. This is usually expressed as matrices, for example:

Origin \ Destination	City centre	Neighbourhood 1	Neighbourhood 2
City centre	100	50	50
Neighbourhood 1	500	80	150
Neighbourhood 2	800	200	300

w. If available, we need to get this information, including the definition of each area (e.g. what exactly does "City centre" means).

The city center mainly (commercial hub), like saddar in Karchi.

x. They may have similar matrices for other data, for example the average travel time by origin-destination pair, or the average fare for a given mode, etc.

This data is unavailable with the secondary sources.

After collecting all possible information from secondary sources, you should validate it against data provided by commuters. The idea is to ask a small sample of commuters about their trips, record their answers, and later compare them to the information gathered from the authorities. Does it match? The things to ask commuters:

- Origin and destination of trip

The origin and destination varied for each commuter surveyed. For example, most of the mini bus trip originated from Liyari ended in shershah (destination). Similarly, the most of the orange line commuters from trip originated from baldiya ends at Aziz Nagar and saddar areas.

- Description of the trip: how many legs? Mode, fare, access, waiting and travel time of each leg.

(8/15) commuters are using single mode that is minibus and (7/15) using more than one mode.

- Purpose of the trip

(12/15) were doing work trip (going to offices and jobs).

- How often the trip is made

5 and 6 Days a week.

- What other alternative ways to travel the person could have used? Not very interested in other possible routes using the same modes, but on other modes that could be used, e.g. driving and taking a taxi instead of public transport, or the metro instead of the bus.

Taxi/Uber and Careem are alternative options.

A lot of this and other relevant information is available in ***origin – destination surveys*** which you will have to access and acquire. Also, provincial governments (especially Punjab government) have their master plans and datasets on transport.

Appendix – II

Example of choice cards used in 1st pilot survey

	Van	Minibus	Bus	Metro-bus	Car-pooling
Access time	20 min	25 min	5 min	15 min	30 min
Waiting time	15 min	20 min	5 min	25 min	25 min
Travel time	75 min	30 min	90 min	20 min	60 min
Transfers	2	3	3	0	0
AC	✓	✗	✓	✗	✓
Free Wifi	✗	✓	✗	✓	✗
Reserved ladies' seats	✗	✓	✓	✓	✗
Service provider	Government	Private company	Private company	Individuals	Government
Fare	35 ?	30 ?	15 ?	30 ?	30 ?

Example of choice cards used in 2nd pilot and final survey

11	Van	Minibus	Bus	Metro-bus	Car-pooling
Walking time	20 min	25 min	5 min	15 min	30 min
Waiting time	15 min	20 min	5 min	25 min	25 min
Travel time	75 min	30 min	90 min	20 min	60 min
Transfers	2	3	3	0	0
AC	✓	✗	✓	✗	✓
Free Wifi	✗	✓	✗	✓	✗
Reserved ladies' seats	✗	✓	✓	✓	✗
Service provider	Government	Private company	Private company	Individuals	Government
Fare	35 ?	30 ?	15 ?	30 ?	30 ?

Appendix – III

Public transport questionnaire for Islamabad and Lahore

1. Survey site (1) Islamabad (2) Lahore (3) Karachi
2. Gender (1) male (2) female
3. Respondent age (years) ______
4. Respondent education (Number of years of schooling) ______
5. Household size _____________
6. Monthly household income (Rs) (1)= upto 49,999 (2)=50, 000 – 99,999 (3)= 100,000 – 199,999 (4)=200,000 – 399,999, (5)= 400000+
7. Number of days in a week you use public transport? ________
8. Number of days in a week you commute? ________
9. What is your average commuting cost (including careem/taxi/riksha) per day (Rs) ________
10. What would be your daily average commuting cost (Rs) if there is relaible public transport ________
11. How many days per week do you use careem/taxi/riksha because of the lack of public transport? __
12. How much you paid for careem/taxi/riksha in the last week? __
13. Per day number of hours you could save if public transport is relaible and efficient _______
14. Public transport in your area is managed by (1) individuals (2) private companies (3) government (4) don't know
15. In your opinion, which of the above *three* would provide a better public transport? _______
16. Have you ever quit a job or did not take one because of the lack of public transport? (1) yes (2) no
17. What are your per hour wages (rough idea) (Rs) ___________.

18. Please describe your current journey:

	Single journey	1st transfer	2nd transfer
Access time (minutes) For how long did you walk get to the *[mode]* stop?			
Waiting time (minutes) How long *did/do* you expect to wait in *that/this* stop?			
Mode (van, minibus, bus, metro bus, other) What mode *did/will* you use in that stop?			
Travel time (minutes) For how long *did/will* you ride the *[mode]*			
Walk to next destination (minutes) After alighting, for how long *did/will* you walk?			

19. Using a scale from 1 to 5, where 1 means "very unsatisfied" and 5 means "very satisfied", please state your level of satisfaction with the following ***features of the public transport***:

Features of the public transport	1	2	3	4	5
Overall service					
Ease of access to public transport					
Frequency (i.e. how often they come by)					
Timeliness (i.e. you will arrive on time and there will be no extended delay in your journey)					
Comfort while in the public transport					
Safety and security while in the public transport					
Coverage of the public transport in your city					
Ladies reserved seats					
The level of respect & cordiality from staff and other passengers towards you					
The level of respect & cordiality from staff and other passengers towards women					

20. Are you aware of car-pooling system? (1) yes (2) no
21. Have you ever used it? (1) yes (2) no
22. Would you be willing to subscribe to a car-pooling system? (1) yes (2) no

Appendix – IV

Public transport questionnaire for Karachi

1. Survey site: (1) Islamabad (2) Lahore (3) Karachi
2. Gender: (1) male (2) female
3. Respondent age: ______ (years)
4. Respondent education: ______ (Number of years of schooling)
5. Household size: ______ (people)
6. Monthly household income (Rs):
   (1)up to 49,999 (2)50,000 – 99,999 (3)100,000 – 199,999 (4)200,000 – 399,999 (5)400,000+
7. Number of days in a week you use public transport?: ________
8. Number of days in a week you commute?: ________
9. What is your average commuting cost (including careem/taxi/riksha) per day?: ________ (Rs)
10. What would be your daily average commuting cost if there is reliable public transport?: _______(Rs)
11. How many days per week do you use careem/taxi/riksha because of the lack of public transport?: ______ (days)
12. How much did you pay for careem/taxi/riksha in the last week?: ___
13. Per day number of hours you could save if public transport is reliable and efficient? _____ (Hours)
14. Public transport in your area is managed by: (1)individuals (2)private companies (3)government (4)don't know
15. In your opinion, which of the above *three* would provide a better public transport?: _______
16. Have you ever quit a job or did not take one because of the lack of public transport?: (1)yes (2)no
17. Please describe your current (or latest) journey:
18. Main mode (the one you travelled by the furthest):
    (1)Van (2)Mini-bus (3)Bus (4)Metro-bus (5)Rickshaw (6)Qinchi (7) Car (8) Other:_________
    Total length of trip: Access_____ (minutes) Waiting ______ (minutes) Travel_________ (minutes)

19. Using a scale from 1 to 5, where 1 means "very unsatisfied" and 5 means "very satisfied", please state your level of satisfaction with the following ***features of public transport (PT) in your city***:

Features of the public transport	Mark (1-5)
Overall	
Coverage PT is easily accessible from your origin and destination	
Frequency PT vehicles come by often	

20. Using the same scale from 1 to 5, where 1 means "very unsatisfied" and 5 means "very satisfied", please state your level of satisfaction with the following ***features of EACH public transport mode***:

Features of each public transport mode	Van	Mini bus	Bus	Metro bus
Reliability/Timeliness You will arrive on time with no extended delay				
Comfort You feel comfortable while travelling in the mode				
Safety You feel safe and secure while travelling in the mode				

21. Are you aware of car-pooling system?: (1)yes (2)no
22. Have you ever used it?: (1)yes (2)no
23. Would you be willing to subscribe to a car-pooling system?: (1)yes (2)no

Appendix – V

Pilot Surveys

A pilot survey is a pre-condition for the primary data collection as it is used to test and improve the survey instrument/questionnaire with actual respondents. However, piloting a choice modelling survey is extremely crucial and a requirement without which it impossible to design and conduct a choice modelling survey. As stated above, piloting in a choice modelling survey is necessary to collect the priors which are required to create the experimental design. This is in addition to testing the survey instrument itself which is also more complex for a choice modelling survey as it involves the experimental design, description of choice scenarios, visuals and the survey questions. Two pilot surveys have been administered in present research.

After collecting 90 responses, 30 in each city under study, we estimated a simple choice model using the collected data. Results are shown in the Table 2 below. This model was not satisfactory, as the coefficients for access and waiting time, as well as the coefficient for travel time for Van and Metro-bus were positive. A positive coefficient means that respondents prefer higher values of those attributes. In other words, this model implied that the longer a trip took, the most appealing it was for respondents. This contradicts basic theory in transport studies and economics, which states that time is a scarce resource, and therefore individuals prefer to spend less rather than more time in unproductive and displeasing activities such as travelling.

Parameter estimates using data from pilot 1

MNL			
		Estimates	t-ratio
Alternative specific constants	Van	-1.2175	-2.22
	Mini-bus	-0.1195	-0.24
	Bus	-0.1971	-0.39
	Metro-bus	0.0000	(fixed)
	Car pool	-0.8706	-1.49
Time (minutes)	Access	0.0018	0.30
	Waiting	0.0067	0.92
	Van	0.0124	2.05
	Mini-bus	-0.0056	-1.09
	Bus	-0.0069	-0.99
	Metro-bus	0.0002	0.04
	Car pool	-0.0157	-1.90
Transfers		-0.4922	-6.69
Perks	AC	1.0748	6.56
	Wifi	0.5913	4.17
	Ladies' seats	0.6523	4.66
	x female	0.5797	1.40
Operator	Individuals	0.0000	(fixed)
	Private	0.0786	0.47
	Government	0.3223	2.07
Fare		-0.0892	-10.80
Fit	LL	-398.55	
	Rho2		0.31
	No. of parameters		19
	Observations		360
	Respondents		90

After examining these results, we hypothesised that respondents were not paying enough attention to access, waiting and travel times due to the visual design of the survey. We believe that the colourful tick and x marks were preventing participants from paying attention to the numeric time attributes. Therefore, we decided to present the time attributes in a visual manner in a second pilot. Additionally, we decided to change the order of the survey in the second pilot, presenting the choice experiment first, and the travel questionnaire second, to avoid the respondent being fatigued by the time they answered the choice exercise.

Parameter estimates using data from pilot 2

MNL			
		Estimate	t-ratio
ASC	Van	-0.4652	-0.83
	Mini-bus	-0.1449	-0.28
	Bus	0.0625	0.17
	Metro-bus	0.0000	(fixed)
	Car-pool	-2.1551	-3.21
Time	Access	-0.0260	-1.64
	Waiting	-0.0175	-0.91
	Travel	-0.0945	-8.46
Transfers		-0.1831	-1.06
Perks	AC	3.0854	6.95
	Wifi	1.2716	3.82
	Ladies' seats	1.7976	4.71
Operator	Individuals	0.0000	(fixed)
	Private	-0.7602	-2.17
	Government	-0.3532	-0.95
Fare		-0.0086	-0.63
Fit	LL		-63
	Parameters		14
	Observations		120
	Respondents		30

Using the responses from the 30 new individuals in the second pilot, a new model was estimated, obtaining the parameter values exhibited below. As the number of observations was lower than in the first pilot, we estimated a simpler model, with a single travel time coefficient for all modes. This time, all coefficients shown the expected sign: negative for all time, transfers, and fare parameters, and positive for AC, wifi, and ladies' seats (Table 3). The level of significance of the parameters is not relevant at this stage, as the sample is very small, and they are expected to improve when a bigger sample is collected and analysed.