Improving Access considering Commuters' Perception (A Case Study of Lahore BRT)

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ABSTRACT

This study aims to improve the accessibility by introducing a regular feeder service over informal conventional feeder modes. A questionnaire survey is conducted to evaluate the commuters' perception regarding current access modes, in Lahore; the study area. The results reveal that paratransit is the most frequent feeder mode than the convention public bus. However commuters are found to be dissatisfied by the quality of paratransit service. It is found that commuters perceive the factors related to the physical body of vehicle i.e. comfort, safety and emission, worst of all. The influence of perception about feeders' quality over the BRT accessibility is modeled using structural equation modeling. Results reveal that vehicular based aspects of current paratransit feeder degrades the accessibility however cost and time have positive impact. Furthermore potential of a regular feeder service is evaluated by adding an observed variable of 'willingness to pay for feeder', which shows a significant positive impact. The poorly designed paratransit and higher WTP endorse the urge of a regular feeder service to enhance the accessibility.

Keywords: feeder, paratransit, accessibility, bus rapid transit system

1. INTRODUCTION

The overwhelming demand of travel and higher use of private vehicle is a day by day increasing phenomena. Consequently, the issues like higher emission polluting the environment, severe traffic congestion and fatal road accidents have become threats for human life. In order to cope with these issues many countries around the globe have initiated sophisticated travel alternatives in the form of efficient mass transit system that offer high mobility and are aimed towards commuters' modal shift. However a growing concern for these public transportation systems is its inability to encourage people to switch their mode of transportation from solo driving to shared driving (1). It is recognized that, this intended modal shift can be achieved by focusing *accessibility* of these systems as well. Enhancing accessibility incorporates urban transportation policy and planning of cities to propagate sharing of alternative modes and to diminish car dependency, which is the ultimate goal (2). Identifying the fact, many transit agencies introduce low capacity bus/ shuttle service as feeder. These feeders penetrate through the area and offer efficient first or/and last mile connectivity to the commuters.

A positive relationship is found between feeder bus network and the mass transit systems' level of ridership (3).

According to TCRP (2009), feeder bus is a desirable option for passengers that live further than walking distance to transit stations, especially for those who do not have private vehicles or cannot afford cost of parking at transit stations. (4).

Conversely in several developing countries, role of paratransit as a feeder mode is emerging rapidly. Many researchers have recommended paratransit to be used as a feeder mode to enhance the mobility, utilizing existing available resources (5,6,7). Though most of these paratransit are quasi-informal and fail to provide efficient access to the main system. Paratransit services seem to satisfy captive rider's needs in terms of mobility especially in feeder function, however the qualities of services do not satisfy the users' needs (5). As a result the expected target of modal shift has not been achieved yet. Researchers also suggested several improvement policies for paratransit to integrate existing paratransit as a feeder system and enhance mass transit attractiveness (5, 6). The current paratransit are informal, poorly organized and not satisfactory at all. Though provision of regular feeder bus service requires vigilant planning and careful design to achieve the target.

This study; evaluates the feasibility of substituting the informal paratransit with the feeder bus service based on the commuters' perception towards paratransit. Technique of structural equation modelling is applied to investigate the influence of commuters' perception towards paratransit, over current accessibility of the main system. Furthermore potential of new feeder bus over conventional paratransit feeder is assessed.

2. CASE STUDY AREA CHARACTERISTICS

For the study purpose, Lahore; second largest metropolitan city of Pakistan, is selected as the subject area. The current population of Lahore is almost 8.65 million, increasing at a growth rate of 3% per year whereas population density is 48 persons/ ha. The vehicle growth rate has reached up to 17% per year between 2004 and 2008, almost five times more than the city's population growth rate (8). According to master plan study, conventional public transport system was highly fragmented and inefficient and made only 20 % of modal share (8). A mass transit system in the form of Bus Rapid Transit System (BRT) (also termed as Lahore Metro Bus) was initiated in early 2013, on one of the most feasible

corridors; Ferozpure Road (FPR) as recommended in master plan. The system connects the two extremes and runs in midst of the city, N-S direction, targeting several prime locations. The excellent location of the system provides direct access to several workplaces including offices, activity centers and commercial areas. The corridor length is 27 kms, with barrier-controls, automated off-board fare collection, well-designed signage and information systems and a precision bus docking system.

However the access to this system is still crucial since it is neither provided with feeders nor integrated with current public modes. Officials believe that other modes, mainly paratransit are serving well as feeders, and while claiming so they are neglecting inefficiency, malfunctioning and poor standards of paratransit, compared to BRT. Other public transport modes include; conventional public bus, wagon, motorcycle rickshaw (qingqi), auto rickshaw and taxi. Among these modes, motorcycle rickshaw is most frequently used feeder mode and therefore in the study term; paratransit accounts for motorcycle rickshaw only.

However this paratransit is limited to certain parts of the city, particularly low profile areas and their movement is restricted in several areas. The potential passengers are mostly low income class.

3. RESEARCH STRUCTURE AND DATA COLLECTION TECHNIQUES

The study is comprised of mainly two parts; the first part is measuring the quality of current access mode. This is achieved by analyzing the commuters' perception and the second part is about assessing the potential of regular feeder bus. For this purpose; a questionnaire survey (interview type) is conducted at selected BRT stations. The questionnaire has two main sections; firstly the respondents are inquired about their socioeconomic and trip information which includes social income class, vehicle ownership, trip purpose, feeder mode and frequency of using BRT. In the second part of the questionnaire, they are required to grade the quality of the feeder mode using Likert scale. For this purpose six service quality attributes are selected empirically; *Route Reliability (RR), Travel Time (TT), Travel Cost/ Fare (TC), Comfort And Convenience (CC), Safety And Environmental Aspects (Emissions) (EA).* This part also carries a question to know respondents' willingness to pay for a new feeder bus by answering either 'yes' or 'no'.

For the study purpose only those trips are recorded that are made by using some auto feeder mode, and not walk. Total 379 samples are collected with the help of university under graduate students.

## 4. RESPONDENTS' SOCIOECONOMIC CHARACTERISTICS

The survey is conducted at selected BRT stations and so all the respondents are BRT users, though the frequency of usage varies individually which is also inquired in the questionnaire. A significant majority of respondents is Male 93%. Almost 62% respondents belong to low income group whereas 61% own no vehicle and so are transit captives. Most of the commuters have work as trip purpose. 49 % of the respondents use BRT on daily basis, whereas 27% use at least once per week. Among the feeder modes two modes are found in which share of paratransit is dominantly higher than that of conventional public transport. The detailed distribution of socio-economic characteristics are shown in Table 1.

5. ANALYZING COMMUTERS' PERCEPTION

5.1 Overall Distribution Of Perception And Average Response

The results of the overall distribution of commuters' perception for the two existing modes, along with the average responses, are presented in Fig. 1. About 43% of commuters consider *route reliability* bad for paratransit, whereas for public transport lesser percentage of commuters perceived it bad, 28%. In case of paratransit, mostly route is not reliable, also the deviation from main route and stops to avoid congestion or to serve certain areas at certain time is unknown to passengers. Whereas conventional public buses are assigned on set routes and stops and hence are more route reliable. But even though collecting and dispersing the passengers from any point, on their way, is quite common. The term, *travel time* is generalized one that includes all the time losses, a commuter has to suffer from one's origin to the BRT station. It can be expressed as;

Travel time = access time to reach the stop (of feeder) + waiting time for feeder + in-vehicle travel time + access time to reach BRT station
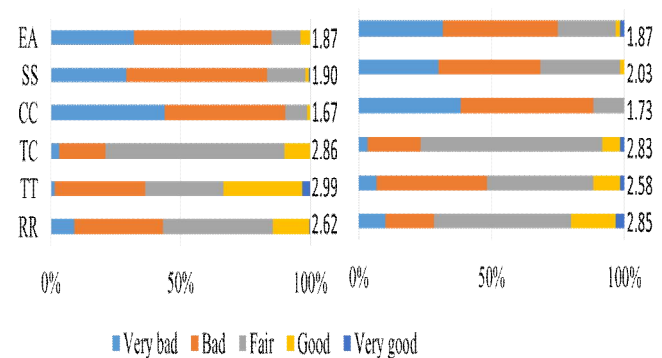
(a) Paratransit   **(b) Public Bus**

Figure 1: Commuters' perception for Service Quality Attributes

A higher percentage of commuters' respondents (48%) perceives the travel time worse for public transport than that of paratransit (36%). The mobile and flexible nature of paratransit render them time efficient, about 33% respondents consider it good. Whereas the operation of conventional public transport is slower, due to; their large size, being often stuck in traffic jams, and so move with lesser speed.

Both paratransit and public transport have varying *travel cost* (fare), roughly based on the distance. Most of the respondents show neutral opinion being 'Fair', towards this attribute; 69 and 68% for paratransit and public transport respectively. However paratransit has a little edge, due to cheaper and negotiable fares. For public transport, fares are set by the transit agencies and fixed.

Table 1: Respondents' Socio-economic Characteristics

Socio economic Category and distribution		% Distribution	Socio economic Category and distribution		% Distribution
Gender	Male	93.1	Trip purpose	Work	76.3
	Female	6.9		Education	13.2
Income level	Zero	17.9		Other	10.6
	Low	62.3	Feeders 'modal share	Paratransit	84.2
	Middle low	18.7		Public transport	15.8
	Middle high	1.1	Frequency of using BRT	Daily	49.2
Vehicle ownership	Bicycle	5.3		Once per week	27.0
	Motorcycle	31.7		Rarely	23.8
	Car	1.6	-	-	-
	None	61.5	-	-	-

The attribute; *comfort and convenience* is related to the riding quality, seating and boarding/alighting comfort of the vehicle. Results show that majority of the commuters perceive this attribute the worst of all. For paratransit 90% and for public transport almost 88% mark it 'bad and very bad'. The results imply that both the modes are deficient in providing comfort and convenience to the passengers. These findings further validate the facts regarding paratransit service that they offer quite bumpy and uneven travelling with the rage driving. The parameter; *safety and security* comes out to be another significant parameter that needs to be considered. For paratransit a relative larger percentage 83%, seems to be dissatisfied, however for public transport its 68%. This higher percentage of dissatisfaction from the commuters is due to the vehicle's physical aspects. The accidents due to vehicle's instability are often observed in case of paratransit. (As the whole body is attached to a motorcycle therefore by loading more weight/passengers on rear side, vehicle often turns over.)

Environmental aspect is the second largest dissatisfied attribute after comfort. It holds for the air and noise emission from the vehicle. For paratransit 85% commuters perceive this poor, while 75 % for public transport. Paratransit are also blamed for 80% city's pollution by the city's environmental department, due to not only the air pollution but the extreme noise, generated from their engine. As per the commuters' average response measurements, monetary attributes of travel time & fare and route reliability have overall positive evaluation, though travel time and fare are weighted higher than reliability. Whereas the attributes of riding comfort, safety and vehicular emission have most negative evaluation. Since the feeders 'modal share results show that share of paratransit is much higher (84%) than that of public transport, these results can be fairly more associated with the paratransit vehicle.

5.2 Factor Analysis

A factor analysis is conducted to find the latent factors among the observed variables. The observed variables are the commuters' perception against the six attributes. The examination of the Kaiser-Mayer-Olkin, measure of sampling

adequacy suggested that the sample is factorable. The reliability of the data is also within acceptable range, as measured from the Cronbach's Alpha (0.775) (Table 2). When loading less than 0.50 are excluded, the analysis yielded a two-factor solution with the simple structure.

Table 2: Rotated Factor Loadings for Service Attributes

Observed Variables	Component	
	1	2
Route Reliability		.649
Travel Time		.824
Travel Cost/ fare		.926
Comfort & Convenience	.852	
Safety & Security	.735	
Environmental Aspects	.842	
Eigen Value	2.834	1.510
Kaiser-Mayer-Olkin measure of sampling adequacy	0.694	
Cronbach's Alpha (α)	0.775	

Note: All the correlations were significant at 1%

As per the factor analysis results, three items are loaded onto Factor 1. These items are related to comfort, safety and emission and therefore linked with the structure of the vehicle and its physical aspects; and therefore labelled as *'Perception about Vehicle Based Deficits' (VBD)*. The other three items are loaded onto Factor 2 and are related to monetary attributes and operation of the feeders. This factor loads onto commuters' reported perception about total travel time from origin to BRT

station, service fare and route reliability. The travel time can also be taken as the cost of travel; therefore this factor is labelled as *'Perception about Cost and Reliability based Deficits' (CRD).*

These two extracted factors reveal that respondents responded the same way for each attribute in each factor for example; the way people responded to travel time is consistent for travel cost and reliability. The indicators or observed variables with higher factor loading have more influence in explaining the corresponding factor. Based on the results it is argued that commuters evaluated cost and reliability aspects positively, in which travel cost is most positively and reliability is least positively ranked. Conversely the evaluation for vehicle based aspects is on the negative scale, resulting comfort as the most negative evaluated indicator and vice versa.

5.3 Structure Equation Modelling

Structural equation modeling (SEM) is a family of statistical models that seek to explain the relationships among multiple variables. This technique is widely used in the field of transport and behavior research as it has the ability to test multiple hypotheses at one time with multiple dependents and constructs (9,10,11). The assessment of fit of the whole model may be judged by means of three major measures of overall fit; Overall χ^2 measures, Goodness of fit index (GFI) and Adjusted goodness of fit index (AGFI), and Root mean square residual (RMR) (11).

5.3.1 Influence of Commuters' Perception over Current BRT Accessibility

A measurement model is constructed, using two factors as extracted from the factor analysis. The objective of the model is to evaluate the commuters' perception for extracted factors. The results of the model show positive and significant standardized regression weights for all the observed variables at 1% (Fig.2). The perception of commuters regarding environmental aspects and comfort has higher influence on vehicle based deficits. Similarly route reliability is weighted more than travel time and cost. This means that these are relatively influential and contribute more towards deprivation of current feeders. The indices of goodness of fit parameters are lying within the permissible range, which indicates that the given model has good fit in predicting the commuters' perception regarding current feeders. This measurement model is further used in assessing the influence of current feeder's deficits over the BRT accessibility by constructing a structural model representing, commuters' perception affecting BRT accessibility (Fig 3). In this model, availability of feeder, cost incurred ($\leq$ 15PKR) and distance covered by feeder ($\leq$ 5kms)

are also assumed to be the indicators of BRT accessibility, therefore used as dummies. These variables show significant positive impact on accessibility which implies that higher availability of feeder mode, incurring lesser cost and from lesser distance enhances the accessibility and making BRT more accessible. As per the relationship among latent, cost and reliability deficits have positive influence, only significant at 90% level of confidence, whereas vehicle based deficits have negative influence on the accessibility and statistically insignificant.
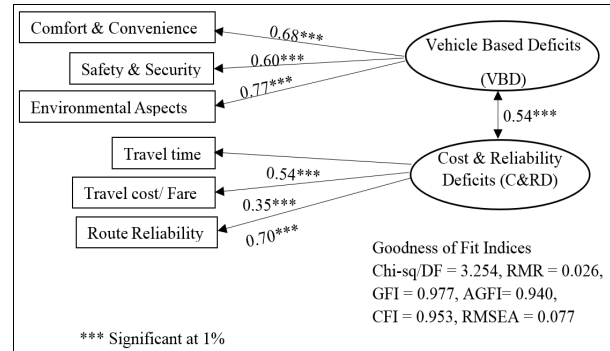

Figure 2. Measurement Model of Commuters' Perception for Feeders

The positive influence of cost and reliability implies that these factors are relatively enhancing the BRT accessibility, though with only 90% confidence. It infers that commuters are more satisfied by these aspects and so have positive perception. Whereas, the negative impact of vehicle based aspects signify the issues related to the feeder's hardware or physical condition. These results indicate that commuters are most dissatisfied by the factors that are linked with the physical condition of the feeder vehicle (motorcycle rickshaw). Being this relationship statistically insignificant implies that, commuters have much lower willingness to go with the current vehicle based deficits, than cost and reliability aspects. Therefore it is inferred that the impact of vehicle hardware is not constructive at all and must be modified to improve BRT accessibility.

5.3.2 Influence of Current BRT Accessibility over Potential of New Feeder Bus

This part is to evaluate the potential of regular feeder bus, other than paratransit, in future. For this
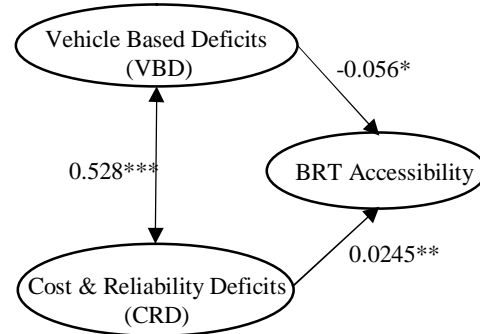
Goodness of fit indices

Chi-sq/df = 3.206; RMR = 0.027 GFI = 0.956; AGFI = 0.917; CFI = 0.892; RMSEA = 0.06

Note: *** Significant at 1%, ** at 5%, * Insignificant

Figure 3: A typical structure of BRT Accessibility based on Commuters' Perception towards feeders

, BRT accessibility along with VBD and C&RD are used as exogenous variables, whereas 'willingness to pay for better

feeder service', is used as dummy. A new endogenous latent variable is introduced and named as 'potential of regular feeder service' (Fig. 4).The results of the model indicate that willingness to pay has significant positive influence on the potential of regular feeder bus/ shuttle in future which boosts the ultimate goal (Table 3). The influence of cost and reliability is also positive and significant at 10 %. On the other side, more negative evaluation of vehicle based deficits and so overall current BRT accessibility rendered their impacts insignificant. This is due to the most negative evaluation of vehicle based deficits, which is also degrading the overall BRT accessibility. Therefore it is inferred that future feeder service must be free from these deficits and so the accessibility would also be not the same. However cost and time efficiency of current feeders is desirable for the future feeder. These results show that there is a potential of a regular feeder service considering inefficiency and malfunctioning of current modes.
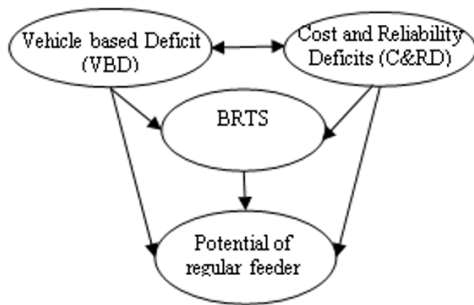

Figure 4. Structure of Finding the Potential of regular Feeder service based on the BRT accessibility

Table. 3. Standardized Regression Weights

Structural Relationships	Standardized Regression weights
Potential_BusFeeder ← VBD	1.656 (p = 0.237)
Potential_BusFeeder ← CRD	3.665**
Potential_BusFeeder ← BRTS_Accessibility	4.280 (p = 0.127)
WTP ← Potential_Feeder service	0.034***
Goodness of Fit Indices	
Chi-square/DF	2.440
RMR	0.020
GFI	0.966
AGFI	0.932
CFI	0.921
RMSEA	0.062

*** Significant at 5%, ** Significant at 10%

6. CONCLUSIONS

The study is aimed to improve the accessibility of a mass transit system by initiating a regular feeder service in place of conventional paratransit service.
For this purpose the service quality of current feeder is measured based on commuters' perception. It is found that deficits in the current feeders which are related to the hardware of the feeder vehicle or vehicle quality i.e. comfort and convenience, safety and vehicular emission are more dissatisfied by the users. These results seem to be very obvious, when it comes to paratransit feeder that offers quite bumpy, uneven and harsh traveling experience. The factor related to environmental aspects which is vehicular emission has highest positive influence on vehicle based deficits. This vehicular emission is more related to noise pollution due to the severe pricking noise produced from the vehicle's engine. This is one of the reasons that these paratransit are banned in several posh areas of the city. Secondly the comfort and convenience offered by this vehicle which is mainly due to the uneven and bumpy riding quality is responsible for the negative evaluation. Conversely, commuters perceive travel cost (or time), relatively better which is due to their higher speeds (being smaller) and negotiable fares. The influence of route reliability is also notable, since most of these feeders follow and run based upon the driver's will, and do not have a regular route and stops.

Their influence over BRT accessibility indicate that vehicle based deficits have negative impact and commuters assign very low scores for theses aspects.

However the impact of cost and reliability deficits is still positive and so is boosting the accessibility. Based upon these results it is inferred that although the current feeder service offers a cheaper and speedy mode, but commuters' perception regarding vehicle based deficits and reliability must be addressed in order to improve the BRT accessibility. A comfortable, convenient, safer, environment friendly and reliable feeder service is more in demand. Most dissatisfied factors are related to the body or the physical aspects of the paratransit, since it is incapable of providing these facilities. Therefore it is identified that there is a strong and valid logic of providing a regular feeder service that mainly deals with the change of vehicle, a small bus or shuttle rather than the old motorcycle rickshaw. Considering the change of vehicle and replacing it with small bus, commuters show strong willingness to pay for the service. The deficiency of current feeder mode due to the vehicular aspects, reliability issues and commuters' willingness to pay endorse the potential of better regular feeder service in the form of small bus/shuttle. A regular feeder bus will definitely improve the BRT ridership by attracting choice riders also. An efficient access to BRT station will prove a supporting step towards modal shift.
The developed structural models can be used to evaluate the commuters' perception for other public transportation modes; e.g. conventional bus service. Also the study will be beneficial in understanding the interpretation of results from structural equation modelling.

This study would help transport planner to understand the key issues related to paratransit service. This study will draw the attention towards loophole in associating an efficient and modern mass transit system to the highly informal paratransit as an access mode. Since a paratransit has a certain service area and potential passengers, and it must be evaluated on these grounds before implementing them as a feeder mode for ALL. It will also help the planners to realize that modal shift cannot be achieved by only providing a central rapid mass transit system but working on the full traveling experience, i.e. access and egress is must at all.

ACKNOWLEDGEMENT

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