Analyzing Contribution of First and Last Mile in Over-all Travel Cost

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Abstract

It is established through literature that without active planning, development can take the form of urban sprawl and land-use changes, resulting in increased travel demand, the loss of carbon sinks, more urban heat islands, and higher per-capita emissions. As a result, as demonstrated by the Sustainable Development Goals, the development of sustainable mobility networks is a critical component of achieving a sustainable city. The contribution of first and last mile connectivity options can make to the environmental sustainability of urban passenger transportation. The first and last mile travel mode is chosen based upon a variety of considerations like the socioeconomic characteristics of commuter including age, gender, economic characteristics, etc., as well as their home and job location if they are employed. Additionally, factors of values and motivations like lifestyle, culture, environment, behavioral aspects, and public awareness also play a major role in mode choice. Augmented first and last mile travel options for passenger transportation have the potential to modify the inherent characteristics of public transportation and reduce the overall costs of trips taken by public transportation, making it more appealing and has capability to transform the passenger transport along with potential to make the entire passenger transportation system as smooth, quick, and comfortable as possible. This includes avoiding delays, waiting time, and transfers, or making them as comfortable as possible if they cannot be avoided. Looking into the importance of first and last mile connectivity in overall success and affordability of public transport the study assesses the present first and last mile travel mode wise travel cost in a Tier-II city (population in range 1 million – 4 million) of India, Jabalpur. The performance assessment parameters were derived from a comprehensive literature review, and the information was gathered from primary survey conducted by Jabalpur City Transport Services Limited, which is a government company responsible for providing transport services in the city, also the data was accumulated from secondary sources like fiscal reports, audited accounts statements, commuters' checks, and expert opinions. The research study emphasizes how mode choice is related to public transportation travel demand, and why it is critical to investigate the implications of first and last mile connectivity. The study will also attempt to focus on the financial implications of public transportation feeder system access and fare egress. The research study is based on Jabalpur city, central Indian state of Madhya Pradesh. The study analyses the trip length, mode choice and travel cost data received from the direct interviews using statistical analysis software and validates hypothesis on impact of first and last mile travel on overall travel cost and using rank correlation method establishes that the first and last mile travel cost is associated and related with the mode choice. The study developed a regression model where the travel cost can be estimated given the mode choices, origins and destination, the model will prove useful to the commuters in making their travel choice and mode choice decisions. The study's final results will be useful to policymakers and administrators in developing countries. This will be useful in urban transportation governance by efficient decision making and policy formulation to increase the profitability of these systems.

Keywords

First and last mile, contribution, travel, cost

1. Introduction

All cities encounter the provocation of developing and providing efficient, healthy and ecologically friendly mobility. The first and last mile of the public transport trip is a critical component in deciding the overall quality experienced by a transit user. When the concept of First Mile Last Mile (FMLM) is applied to public transit, it basically emphasizes the challenges confronted by potential users and actual users of public transit by looking into cost, efficiency, logistics, and comfort; and deciding whether to use public transit or not. FMLM is generally associated as the first and last leg of a user's trip. This acknowledges that the passenger experiences the trip from origin to destination as a whole, and that the quality of the first/last mile (1LM) part may determine the overall satisfaction with the trip. The multimodal and diverse nature of the 1LM environment is rarely dealt with, while studying the individual modes used during the first/last mile (1LM) trip, such as walking and feeder buses. This has significant consequences for long-term transportation goals, since the success with which passengers are drawn to and maintained on public transportation modes may have nothing to do with the quality of the modes themselves if the rest of the route is unpleasant. This could have ramifications for the efficiency and equality of transportation systems (Boarnet et al., 2017); (Venter, 2020a).

The improvement of transit accessibility and overall performance of transit services is fabricated by better understanding of the access and egress modes that support transit trips in first and last mile. According to several studies, commuters' socioeconomic status has an impact on the route of access and egress they choose. The most important criteria that influence mode selection are access and egress time and distance. The transportation component assesses the ability to get access/egress and is influenced by the spatial and temporal coverage of services, travel costs (e.g., journey time), and user satisfaction with the service. Micro-level characteristics such as population density, employment density, land-use mix, and transportation infrastructure near the station area, as well as trip origin, were found to be associated with mode choice decision. The transportation component of the analysis characterizes the ease of travel, and is usually described with a cost function. Although FMLM alternatives are not new, currently there is only small-scale research on the FMLM and its significance in the transportation service. They have evolved throughout the last two centuries and are still evolving. The underlying concept is always the same. Bundling or aggregation of persons or things is required for efficient transportation. Only hubs or stops can be used to organize bundled transportation. An FMLM choice is required to reach the hub or halt.

2. Literature Review

The first-and-last-mile access has received substantial attention in public transit literature. This includes a large body of research on proximity of transit service, station spacing, walking environment, and biking infrastructure (Beimborn, Greenwald and Jin, 2003); (Karner, 2018); (Liu, Jia and Cheng, 2012); (Zuo et al., 2020). More recently, research interest has shifted to multimodality of public transport such as choice of access/egress modes including shared mobility options based on the argument that an integrated multimodal public transit system can help extend the public transit catchment area and increase transit ridership ((Bergman, Gliebe and Strathman, 2011a); (Chandra et al., 2013); (Krygsman, Dijst and Arentze, 2004a); (Shaheen and Chan, 2016); (Venter, 2020b). Previous studies have investigated various factors affecting access and egress mode choice; these factors fall under four major categories: 1) trip characteristics, 2) socio-economic characteristics of the traveler, 3) mode-specific characteristics, and 4) built environment, infrastructure, and station area characteristics.

Access and egress time and distance are the most significant factors that determine the choice of modes. Travelers make tradeoffs between walking and cycling when the distance is shorter and usually choose public transportation modes as the distance increases increases (Bergman, Gliebe and Strathman,

2011b);(Givoni and Rietveld, 2007); (Goel and Tiwari, 2016); (Keijer and Rietveld, 2000a); (Rietveld, 2000). (Bergman, Gliebe and Strathman, 2011c) found that walk access is the dominant mode when the distance is less than a half-mile, while bus become the major access modes for longer distances (greater than one mile). Travel time is also important for mode choice. An increase in access and egress time contributes to additional disutility in travel. If access and egress times are substantially large, commuters are less likely to use public transportation ((Keijer and Rietveld, 2000b; Cervero, 2001; Murray, 2001; Zhao et al., 2003; Gutiérrez, Cardozo and García-Palomares, 2011).

However, inter-urban trips are significantly longer than the intra-urban trips and the extent to which access and egress times result in disutility greatly depends on the overall trip distance (Krygsman, Dijst and Arentze, 2004b). Some studies showed that travelers' socio-economic characteristics also influence their access/egress mode choice. However, the literature is scarce and indicates contrasting findings regarding socio-economic variables. Rapid progress in automated vehicle technology over the last few years opens up the possibility of novel transportation alternatives. The car that drives itself—once a futuristic vision but currently under development in a number of forms—can offer numerous safety, societal, and infrastructure-related advantages. But the transformative power of rapid technological advances need not be restricted to private transportation and can alter people's choices of modes, destinations, and even locations. Cost is always a significant obstacle to overcoming the "last-mile" problem. In low-to-medium density environments in particular, the cost of providing connecting service may not be shared across a high number of passengers because of low vehicle occupancies; this renders the cost per passenger unaffordable, whether in the form of high fares or unsupportable subsidies. (Rahman, Akther and Recker, 2022); (Unterstaller, 1994). Bundling or aggregation of persons or things is required for efficient transportation. Only hubs or stops can be used to organize bundled transportation. An FMLM choice is required to reach the hub or halt.

3. Methodology

This study uses data from a Tier-II city of India with a population in the range 1 million - 4 million, Jabalpur which was collected through a primary sample survey aiming to analyze the contribution of first and last mile in overall travel cost. The target population for the survey was public transit commuters. Questionnaire Survey has been conducted over 13 routes spread across 30 bus stops with 1275 respondents. In order to select the respondent a random sampling method was used for this data collection exercise and out of 13 routes the maximum route length is 34.1 km having 72 bus stops and the minimum route length is 10.1 with 38 bus stops. The survey was conducted at 30 distinct bus stops covering all the operation routes by Jabalpur City Transport Services Limited (JCTSL). The survey includes questions like origin, mode of travel to the bus stop, purpose of journey, distance traveled to arrive at the bus stop, fare for the access trip, waiting time at the stop, information regarding access of the trip, other questions revolving around main trip characteristics like alighting point, main mode, approximate fare, main mode of travel, along with the queries regarding egress of the trip like final destination, which mode will you choose if the destination is not near the stop, average waiting time for the next mode, approximate distance and time, fare of egress. After the data was collected from the site, the data was punched on data analysis software and was cleaned for errors and ambiguities. The data was analyzed over the parameters like, the mode choice for first and last mile travel, the average fare of first and last mile travel and mode by mode analysis of average trip cost versus the average first and last mile trip. This data analysis is presented in this manuscript and with the advancement of research the data will also be analyzed on attributes like spatial setting of bus stop i.e., impact of location of bus stop outskirts, city center or urban fringe versus the cost of last mile travel.

4. Site Selection

The case study is centred in Jabalpur, a megacity in the Madhya Pradesh state in central India. Motorable roadways give good connectivity to Jabalpur with almost all major metropolises in India.

Table 1: Public Transport of Jabalpur (Source: Jabalpur City Transport Services Limited (JCTSL), Jabalpur)

Route No.	*Origin*	*Destination*	*No. of Bus Stops*	*Route Length*
2	Teen Patti	Ghana (Ranjhi)	54	17.9
4	Trimurti Nagar	Tilwara	50	16.6
5	Teen Patti	Gosalpur / Jujhari	72	34.1
6	Railway Station	Panagar	62	23.5
7	Railway Station	Bhedaghat Dhuandhar	58	21.9
8	ISBT	Barela	44	25.2
9	Damoh Naka	Bhedaghat Dhuandhar	60	24.5
11	Railway Station	Karmeta	48	11.5
12	Deendayal	Trimurti Nagar	46	17.2
13	Railway Station	Bhedaghat Dhuandhar	52	19.9
16	Damoh Naka	Medical via Ranital	38	10.1
22	Railway Station	Shahpura	62	23.4
23	ISBT	Airport	66	31.8

This study focuses on Jabalpur conveyance commuters who regularly travel to the main megacity from near suburban areas it assesses the present first and last mile trip mode wise trip cost in a league- II megacity with population in range 1 million- 4 million of India, Jabalpur.

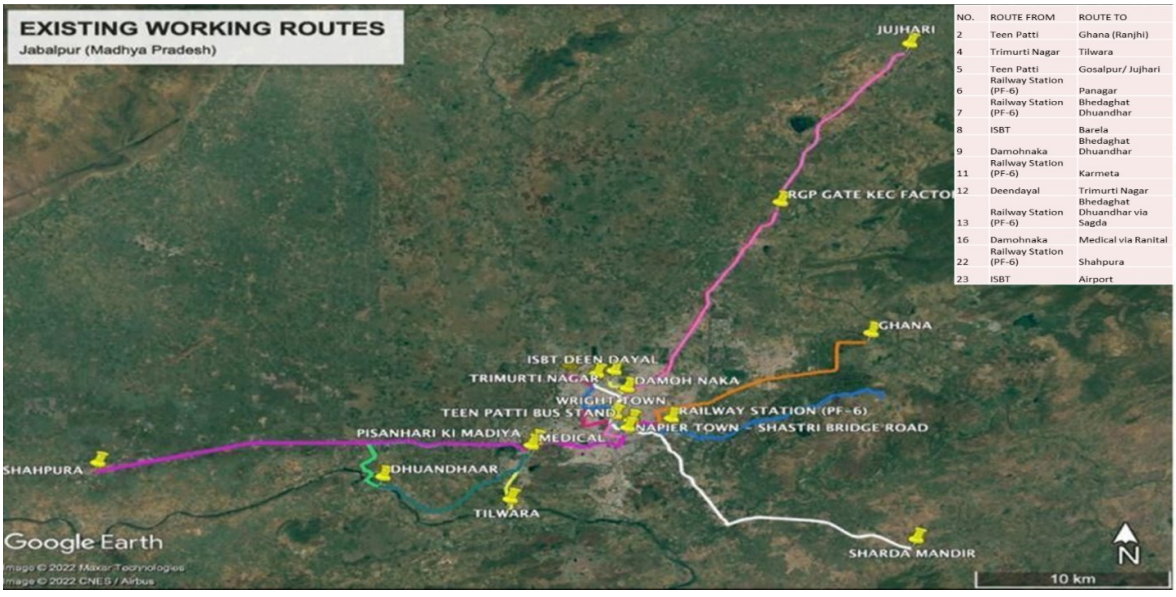

Figure 1: Identified routes and bus stops for the survey (Source: Author)

We administered intercept and on-board checks to understand access and exit trip characteristics of commuters. We interdicted travellers at bus stations, and on-board (in buses), We chose intercept and on- board checks over menage checks and factory checks because suburban commuters make up a small share of the total population, and it's delicate to identify them predicated on their home and factory locales. The spatial settings of the bus routes and the bus stops in relation with the satellite imagery of Jabalpur is very important for reader in order to understand the scale and extent of public transport services. The same may be referred in Figure 1.

5. Data Analysis

Most people preferred to walk the last mile (i.e., 68.8%). Bicycles are the least preferred means of transportation. Of the sample size, only 1 in 1275 people use a bicycle. 1.3% of people use a car for the last mile. Preference for motorcycles and IPT is 16.65% and 13.09% respectively. Also, the cost of using a car for last-mile trips is higher than for the main trip. Therefore, when considering cost, cars are considered the worst option for the last mile. Preferring walking and biking is considered an economical option, as walking is free and parking is rarely required. Using a two-wheeler can match the cost of the main trip, and the IPT is relatively less compared to the cost of the main trip. Overall, the average last mile cost across the city is one-third the average cost of major travel. The last mile to travel is where people walk the least and drive the most. Mode selection based on distance seems to depend on economy and comfort factors.

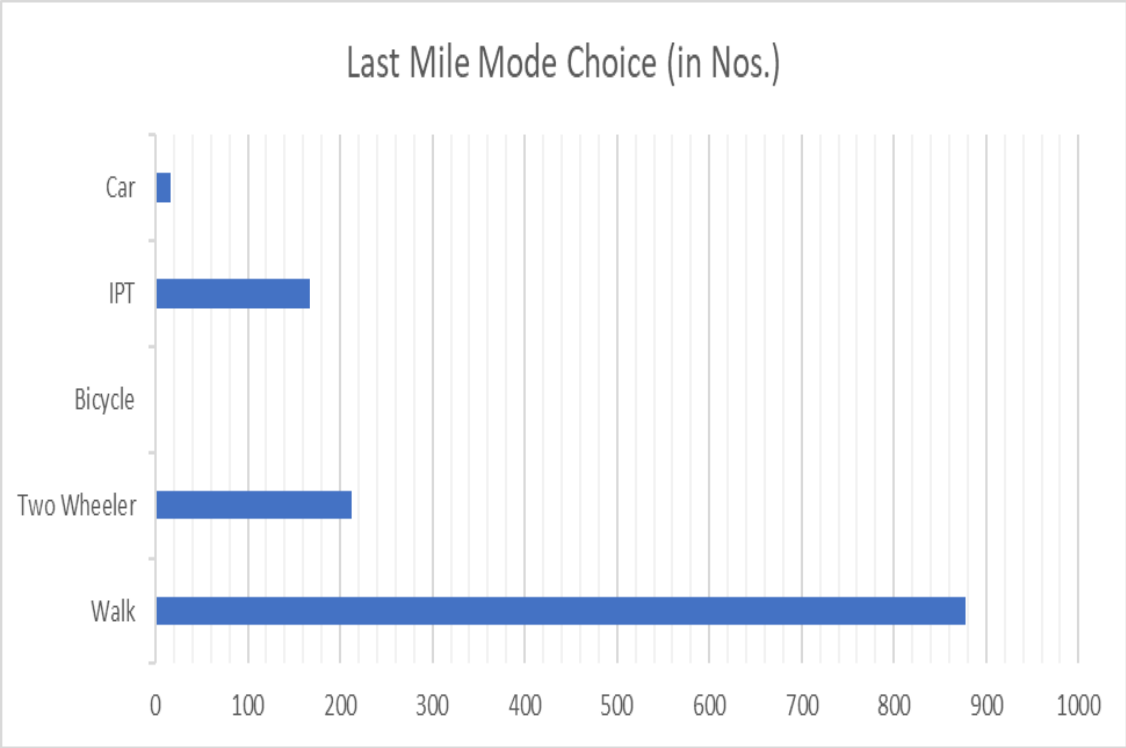

Figure 2: Classification of last mile mode choice (Source: Author)

The frequency of mode selected by the people for last mile to their destinations. The mode choices were walking, bicycle, two-wheeler, IPT and car. The sample size was 1275 out which frequency distribution is done on the basis of user's mode choice. The difference in the average cost of last mile trip and average cost of main trip of the users of all five mode. As there is only 1 respondent of bicycle user for the last mile, it seems that users of all the other modes pays approximately equal fair which means they all travelling almost the same distance using the Main trip. For better delicacy, the locales of origins and

destinations were intrigued on the chart, and corresponding distances in each stage of the trip were measured.

Table 2: Data Analysis (Source: Author)

Mode	*Number*	*Avg last mile trip fare (in INR)*	*Avg trip length (in km)*	*Avg main trip fare (in INR)*	*Contribution of last mile in total fare (in %)*
Walk	878	0.35	0.63	15.60	2.19
2-Wheeler	212	16.25	1.81	16.03	50.34
Bicycle	1	2.05	1.40	6.00	25.47
IPT	167	12.25	2.01	14.85	45.20
Car	17	22.35	2.86	13.82	61.79
Total	1275	4.80	1.05	15.55	23.59

Three types of variables were included in the questionnaire 1) socioeconomic characteristics age, gender, educational qualifications, and occupational status; 2) trip-specific information for available modes travel time, trip cost and number of transfers; and 3) quality attributes of the mode's velocity, safety, comfort, and responsibility as perceived by the trippers.

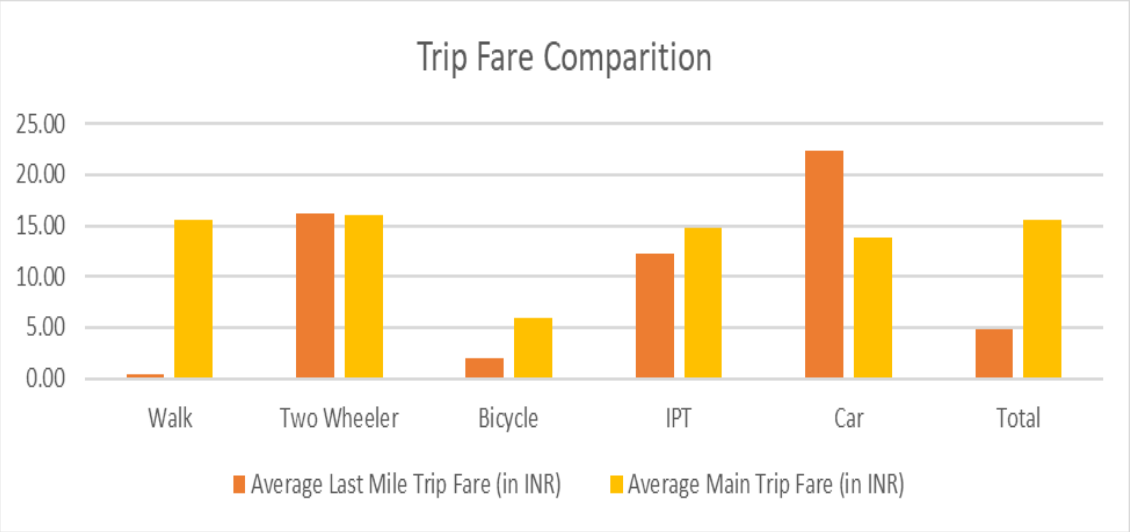

Figure 3: Fare comparison between last mile and main trip (Source: Author)

The Jabalpur City Transport Services Limited (JCTSL) which is a government company responsible for furnishing transport services in the megacity. JCTSL designed a questionnaire check to collect trip related data on commuters' home- work trip. Information regarding trip time (disaggregated into in- vehicle time and staying time), trip cost, and the position of origin, destination, and boarding and alighting stations were included in the questionnaire. The average distance travel by user with a particular mode. Last mile travelled by the user depends on user's threshold, personal comfort affordability, time consumption and personal preferences. The rationale way to get a sufficient sample size is to reach them at vehicle stops and on- board during their transfer trip.

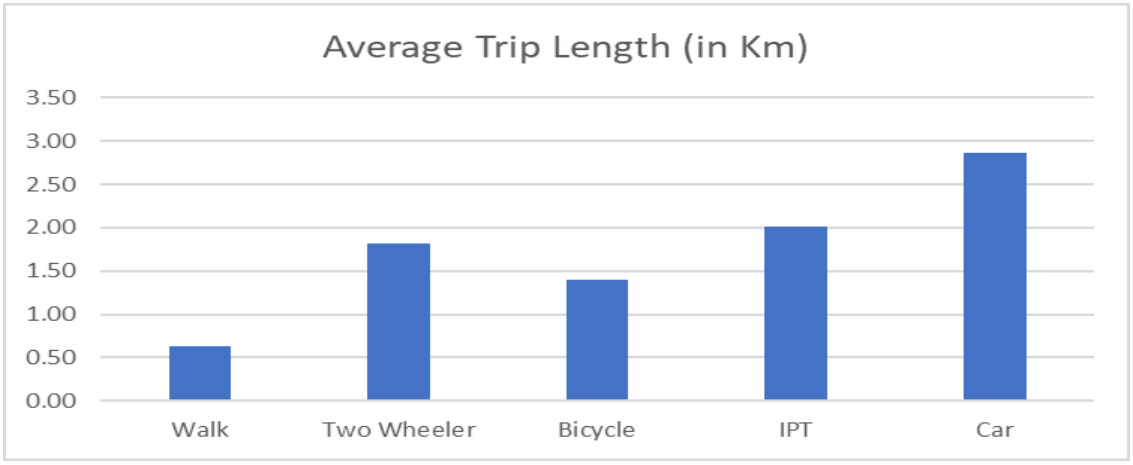

Figure 4: Mode wise average trip length (Source: Author)

6. Study Findings and Recommendations

The study found that walk is the most preferred mode choice for first and last mile connectivity in medium city, Jabalpur. The contribution of walk in the total trip cost is also negligible at 2% of the total trip cost. Most people prefer to walk for last mile, and the reason may be the location of the bus stop, which is close to most places of work. Bicycles have the lowest priority as there is no bicycle parking near the bus stop and the Public Bicycle Sharing (PBS) station located at the bus stops do not have docking provision near the residential and commercial areas, making it difficult for commuters to hire this service as the OD pair is not served. This lacunae in PBS planning have resulted in non-utilization of created infrastructure by the public transport commuters for their first and last mile travel needs. Cars are also less preferred due to higher parking and operation costs. Because those who prefer to drive the last mile take the longest route compared to other alternative options. Intermediate Para Transit (IPT) and two wheelers are often used for distances of about 2 km, and are chosen by people who value convenience and economy. On the other hand, section of the car for last mile depends on affordability and convenience of the user. As a result, it was found that the average travel cost of people in Jabalpur city was one-third of his main travel cost. For short distances, a comfortable and fast mode is selected, and for long distances, a comfortable and fast mode is selected, but the choice may vary based on the user's affordability. A lack of infrastructure, such as parking spaces dedicated to certain modes, can result in certain modes being eliminated or disliked by users. Understanding the impact of the first and last mile of a public transit journey on journey origin and destination in terms of time consumption, overall journey cost, user comfort and mode capacity This is important for how well passengers are served. If the value of any element is higher than the value of the main trip, it is highly likely that the trip as a whole will not provide a good experience for the user. The study observed that in spite of walk and cycling being environment friendly, economical and sustainable mode of transport are neglected to be planned as first and last mile connectivity to public transport.

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