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Position paper

Access–egress and other travel characteristics of metro users in Delhi and its satellite cities

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ABSTRACT

We present details of access–egress as well as other travel characteristics of metro users in Delhi, and its satellite cities. For this study, we conducted an on-board survey of metro commuters ($n = 1112$) in 2011. Survey respondents reported use of seven different modes to access metro stations, with 55% using non-motorized modes. The alternative modes reported by the respondents indicate that, in the absence of metro, a majority of commuters will use bus, and up to 40% will use private motorized modes. Up to 18% of the respondents may not have made the trips if metro was not available, indicating a significant proportion of induced trips. We used multinomial logistic regression models to understand the factors associated with the choice of access–egress modes, as well as alternative mode, for the current trip. Trip length, vehicle ownership, location of metro station (classified as administrative units within Delhi, and neighbouring cities), and population density around metro station have statistically significant associations with the choice of access/egress modes. Alternative modes of metro trips are found to be dependent on trip length and vehicle ownership. We found that up to 88% of metro trips have an interconnectivity ratio with the range of 0.2 to 0.5, with 0.4 as the mean, corroborating the results of [13] for a European setting. The results indicate that this ratio may be universally applicable, thus making it a robust parameter to assess, or forecast, ridership of public transportation systems.

1. Introduction

Delhi has been experiencing a declining mode share of public transportation (PT) trips. From 1994 to 2008, it reduced from 42% [1] to 29% [2]. Since 1990s, auto ownership of the city increased rapidly. During 1991–2000, on an average, 50,000 cars and 100,000 motorized two-wheelers (2W) were registered every year, which almost doubled in the following decade (2001–2010) to 110,000 and 180,000 per year [3]. However, growing auto-ownership in the city was not accompanied by a robust supply of PT. Though development of bus-based rapid transit network throughout the city could have been achieved much faster, however, policy makers preferred metro system instead. Metro in Delhi started its operation in December 2002, with an 8-km line. Its construction has been carried out in phases. With the completion of Phase I and II by 2011, it had an operational network of 190 km, consisting of elevated, at-grade, and underground lines.

From an international perspective of major cities, city-based rail development in Delhi is recent. For instance, in most cities of the industrialized world, city-based rail systems started in the early 20th century — London (in year 1890), Chicago (1897), Paris (1900), Boston (1901), Berlin (1902), New York City (1904), Madrid (1919) and Tokyo (1927). Thus, unlike Delhi, rail development in these cities preceded the growth of private motorization. Prior to the Delhi metro, metro system in India was constructed in Kolkata city, located in the eastern part of the country. This was the first underground railway project implemented in India. Its expected daily ridership after opening of first phase in 1978 was anticipated to be 1.3 million passengers, and in 1990, 1.7 million. However, the number of passengers on the metro during 1999–2000 could reach only up to ~150,000, which is only one-eleventh of the estimated traffic. The system originally estimated to be constructed at a cost of US Dollars (USD) 31 million, was completed at a cost of USD 355 million [4]. Similarly, ridership forecast for Delhi metro could not come close to actual ridership. After nearly USD 4.2 billion spent in its construction [5], in 2009, Delhi metro was operating at a ridership which was one-fourth of the forecast [6]. While success of Delhi metro as a public transport mode is still questionable, its successful implementation fuelled up the inclination of Indian policymakers towards implementation of metro systems in Indian cities. Currently, more than a dozen cities have them under planning or construction stage [7].

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Ridership of metro, or any PT system, is highly dependent on the time people spend during its access and egress parts [8,9], and the level and quality of access [10,11]. Access and egress are the weakest parts of a PT trip since these stages also involve much physical effort ([12] cited in [13]), and occur in an outdoor environment. As a result, with an increase in access and egress time, the usage of public transport decreases [14,15]. Access and egress (distance and time), in turn, depend on the coverage of PT system. The motivation of this study is to understand the access–egress parts of a metro trip in Delhi, and the different factors which influence the choice of access mode. In addition, we have investigated the mode-shift of current metro users. In this study, we present results from an on-board survey of Delhi metro users.

2. Delhi and its satellite cities

Delhi had a population of 16.7 million in 2011 [16], and with a built-up density of ~24,000 persons per square kilometre [17], it is one of the densest cities in the world [18]. Among all the major metropolitan cities in India, it has one of the highest motor-vehicle ownership, and among all states of India, has one of the highest per capita income (Delhi is a city-state) [3]. According to Census 2011, 21% of households own at least one car, 30% at least one motorized two-wheeler (2W), up to 30% own a cycle and 37% households own no vehicle. The ownership categories do not add to 100%, as the categories are not mutually exclusive, and one household can own more than one vehicle type.

In 2008, bus-based PT in Delhi catered to ~27% of the total trips [2], most of which are served by state-run bus system with a fleet of more than 10,000 buses operating on more than 700 routes [19]. Travel demand in Delhi is not only intra-city, but also has a significant share of inter-city travel because of growth of adjoining satellite cities around it. During the last three decades, total population of these cities – Ghaziabad, Faridabad, Gurgaon and Noida (see Fig. 1) – have grown 7 times, reaching 5.3 million in 2011 (Table 1). As a result, this region has become an agglomeration, giving rise to high demand for travel from one of these cities to another.

Table 1
Population and vehicle ownership according to Census 2011.

	Population	Car ownership[a]	2W ownership[b]
Delhi	16,750,000	21%	38%
Noida	650,000	30%	40%
Ghaziabad	2,400,000	18%	39%
Gurgaon	900,000	36%	43%
Faridabad	1,400,000	20%	44%

[a] defined as percent households owning at least one car.
[b] defined as percent households owning at least one 2W.

2.1. Delhi metro system

The network of Delhi metro consists of six lines (named by different colours), and covers not only Delhi, but also reaches some of its contiguous satellite towns — Noida in the east, and Gurgaon in south, just outside Ghaziabad in north-east, and Faridabad in south-east (see Fig. 1). Table 1 shows population and vehicle ownership in Delhi and its satellite cities. In 2011, Delhi metro had a daily ridership of 1.6 million [5]. The trains consisted of both 4 and 6 coaches, which run during off-peak and peak hours, respectively.

2.2. Other forms of public transportation (PT)

A variety of transit and para-transit modes operate in Delhi, which play a vital role in the daily travel of city's population. Para-transit refers

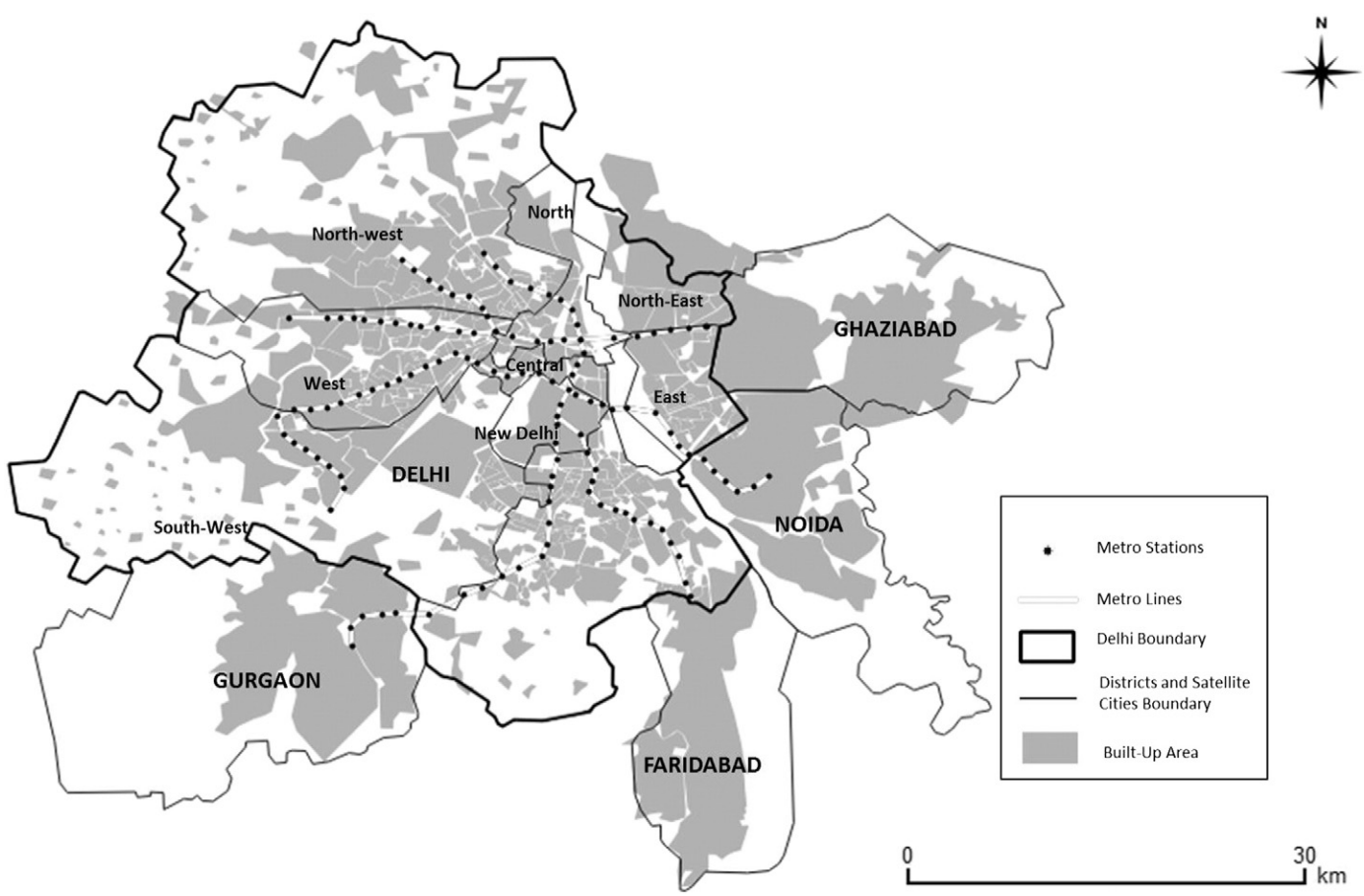

Fig. 1. Delhi metro network, districts of Delhi and surrounding satellite cities.