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Determinants of Intra Urban Mobility: A Study of Bengaluru

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DETERMINANTS OF INTRA URBAN MOBILITY: A STUDY OF BENGALURU

Shivakumar Nayka* and Kala Seetharam Sridhar**

Abstract

Given the importance of intra urban mobility to access jobs and their economic importance for cities, this paper identifies determinants of commuting time for Bengaluru's commuters. Since secondary data on urban commuters is conspicuous by its absence in Indian cities, this paper uses valuable primary survey data of commuters in Bengaluru using a structured questionnaire. The findings are that, the average one-way commuting time to work is 42.45 minutes, to cover an average distance of 10.84 kms, and an average spending of Rs.2,589 per month on commuting to work. We find, based on regression analysis, that those that are educated, men, those travelling during peak hours and those that are married incur a longer commute time. We find that 70.43 per cent of commuters are travelling to work during peak hours and 43.30 per cent of commuters travel more than the commuting time predicted by the model developed here. We conclude that there has been an insignificant decrease in the metropolitan area's effective labour market during 2001-2018.

Key Words: Urban Commuters, Commuters by distance—Bengaluru, Commuters by mode—Bengaluru, Urban transport—GIS, Transport.

Introduction

Cities are rapidly becoming the engines of economic growth all over the developing world, primarily due to their scale and agglomeration economies. As of 2014, the urban population of the world, at 54% as per World Bank data, continued to expand at more than 6 per cent per year in many developing countries. Per capita motor vehicle ownership and use continued to grow by up to 15 to 20 per cent per year in some countries (Gwilliam, 2002). Cities are important as they typically contribute the most to the GDP of a country. In India, though only about 31 per cent of the national population resides in urban areas, they generate over 60 per cent of the GDP (Institute of Urban Transport, 2014), which indicates their importance in sustaining national growth targets.

As is clear, economic growth momentum can be sustained if and only if cities function efficiently and their resources are used to maximise the cities' contribution to national income. A city's efficiency largely depends upon the effectiveness of its transport systems, that is, the efficacy with which people and goods are moved through the city (Singh, 2012). Transportation costs play a critical role in the formation and working of cities (Kanemoto, 2006), since the scale economies and

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agglomeration economies that cities generate depend on work and productivity that take place in jobs of the city.

As Bertaud (2014) points out, a city's 'effective labour market' (the number of jobs accessible within a certain commute) and its economy grow when a larger number of jobs are accessible within a certain commute time. As he reports, within a 30-minute drive, 2.4 million jobs can be accessed in Los Angeles, compared with only 0.6 million jobs in Atlanta, so it is obvious that Los Angeles' effective labour market is much larger than that of Atlanta. Advancements in transport technology have improved the mobility of people and goods, which in turn has contributed to the growth of large cities during the last century. Improvements in transport technology have also made possible the spatial concentration of both people and fixed capital. Hence there should be no doubt that the productivity of a city with a growing population unequivocally increases if travel between residential areas and firms and among firms' locations remains fast and cheap. As a city grows, it is therefore important to monitor mobility by comparing how average travel times and transport costs vary over time (Bertaud, 2014).

The purpose of this paper is to examine if individual commuting time, and hence the metropolitan area's effective labour market, has changed, and how individual commuting time varies based on socio-economic and demographic characteristics, taking the case of Bengaluru, that is known for its massive traffic gridlocks.

Research Questions

The research questions we answer in this paper are as follows:

1. What is the commute time to work of residents in Bengaluru? What does this imply for the city's effective labour market?
2. What are the determinants for commuting time with respect to commute to work in Bengaluru?

Cities are important effective labour markets; hence there is a lot of merit in examining the commute patterns in cities. While the intra city level commuting analysis has not been attempted before with respect to Indian cities, what is the rationale for undertaking the exercise at the city level? As mentioned above, the theory for this is set by the effective labour market as Bertaud (2014) argued, which refers to the number of jobs accessible within a certain commute for a city. Given the lack of secondary data on journey or commute to work for Indian cities, we have collected, through primary surveys, data relating to commute to work. Studying cities level commuting pattern helps us to determine the city effective labour markets. This helps us to understand how Bengaluru is efficient (in terms of commute time) and is able to reap benefits from the greater mobility of its working population.

Bengaluru, the capital city of Karnataka, is amongst the top ten preferred entrepreneurial locations in the world. Bengaluru is known as the technology hub of Asia and Silicon Valley of India because of its role as the nation's leading information technology (IT) exporter. With an estimated population of 8.5 million in 2011, the population of Bengaluru is expected to go up to 9.98 million by 2021 and 11.97 million by 2031. Bengaluru is the fifth largest metropolitan city and third most populous city in India. The cosmopolitan nature of the city has resulted in the migration of people from other states as well as other countries.

Given the lack of primary data and adequate research on commute time, in this paper, surveys of 470 individuals' commute to work at the work place (using a structured questionnaire which was done for a much bigger PhD thesis) for 2018 are used to produce the most detailed examination of commuting time, distance and costs in a major city in India.

The rest of the paper is organised as follows:

- Review of relevant literature.
- Spatial distribution of industries in Bengaluru
- Materials and methods used for the research.
- Findings of determinants of commuting time in Bengaluru
- Conclusion and policy implications

Review of Relevant Literature

The extensive literature on commuting behaviour provides numerous possible determinants of commuting time and distance. For example, Hanson (1982) makes an attempt to understand the effects of two sets of variables on different aspects of individuals' complex travel activity patterns: firstly socio-demographic variables like attributes of the individual and households, and secondly spatial variables like location of the individual relative to potential destination, using the travel diary data (e.g., frequency of travel, dispersion of destinations visited) of Uppsala in Sweden. The main findings of the study are that spatial constraints are important to several travel measures, and socio-demographics remain significantly related to most aspects of travel even after the effects of spatial constraints have been controlled.

The aim of a relevant study by Lee and McDonald (2002), is to understand the determinants of commuting time and distance for Seoul's residents. They used two per cent public-use sample data of the 1995 Korean population census and used multiple regression analysis to identify various determinants of commuting time and distance in the study region. The major finding is that commuting time and distance are longer for male workers, full-time salaried workers, workers with more education, home-owners and male workers in the prime earning years (over age 35). It is found that the household responsibility of childcare is an important factor for the shorter commuting of Korean married women.

Hamilton and Roell (1982) make an attempt to understand the ability of the monocentric model to predict the mean length of commute in an urban area. In this paper, the authors compare actual mean commute with that which is predicted by monocentric models. They calculate the volume of commuting which would result if people chose their house and jobs at random, making no effort to economise on commuting. In this paper, they used volume of commuting pattern from home to job locations for US and Japanese cities. The major finding of the paper is that the actual commuting distance is about eight times higher than predicted by the model and this over predicts actual commuting by about 25 per cent. According to them, one of the primary findings is that the monocentric model does a poor job of predicting commuting behaviour for the given cities.

A study by Adetuji and Aloba (2013) focused on the urban spatial structure and work trip patterns in medium-sized cities and towns of south-western Nigeria. This study mainly examines the

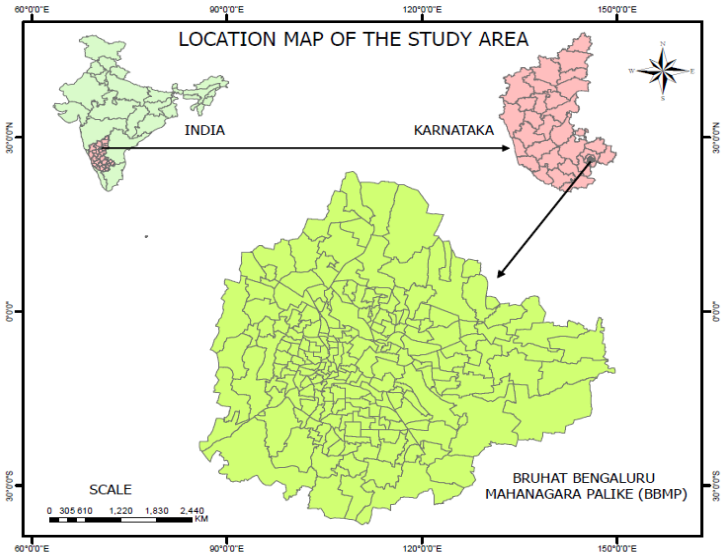
structure of urban work trips in a traditional, but economically, socially and politically dynamic Yoruba town of Ilesa in Osun state, Nigeria. A systematic random sampling procedure was used to understand the spatial structure and work trip patterns across eleven traffic analysis zones. The main finding of the study is that a greater spread of socio-economic facilities would not only enhance accessibility but also reduce the pressure on main transport arteries in the metropolis. The authors also suggest that a renewal of physical planning of Ilesa and cities of similar sizes in Nigeria would facilitate an increase in the mobility of the city dwellers.

As may be clear from the brief survey of the literature presented, there are no papers which study commuting patterns and time in Indian cities, let alone discuss their effective labour markets. This paper attempts to fill this gap.

Spatial Distribution of Industries in Bengaluru

While Bengaluru is the one of the most studied cities in the country as well as the world for its information technology (IT) industry, the city is also dynamic enough to provide space for other sectors like manufacturing, trade and commerce, government departments, and the informal sector, which thrive along with IT. Areas like Chickpete, Cottonpete, Upparpet, Malleshwaram, Gandhi Bazaar, Kempegowda Road, and City Market are famous for trade and commerce sectors (mainly silks and saris), while areas like Peenya, Rajaji Nagar and Yeshwanthpur are the main industrial locations of the city. Government organisations and departments are located in the central part of the city, namely Vidhana Soudha (as Sridhar in her 2007 assumed was the city centre), while some other government departments are located in Multi-storeyed Building, Vishweshwariah Towers, the state High Court and City Corporation and Cauvery Bhavan (all in central parts), and Kendriya Sadan, Koramangala (south).

Map 1: Location and Ward-wise map of Bengaluru city



Source: Karnataka State Natural Disaster Monitoring Cell and Authors' compilation

The Bengaluru Metropolitan Transport Corporation (BMTC), Karnataka State Road Transport Corporation (KSRTC) and Bengaluru Metro Rail Corporation (BMRCL) offices are in the south, Shanthi Nagar. Areas such as Electronic City - Bommanahalli, Marathalli/ Bellanduru, KR Puram, Global Village - Kengeri, World Trade Centre - Yeshwanthpur and Manyata Tech Park - Hebbal are the major locations where IT companies are located in the city (see location map of Bengaluru Map 1). Accordingly, the sample of commuters for the primary surveys was chosen for the respective sectors from the geographic areas indicated above. While there may be IT companies in Yeshwanthpur, and trade and commerce establishments in Rajaji Nagar, our sampling is based on the assumption above.

The present research paper is based on the primary survey data collected from a sample of 470 commuters in Bengaluru, covering the government (100), IT (100), industrial (100), trade and commerce (100) and the informal sector (70), gathered at their workplaces in response to a structured questionnaire. Table 1 and Map 2 provide the details of sector-wise respondents selected and their respective numbers. For the informal or unorganised sector commuters, this study followed criteria according to the definition given by the National Commission for Enterprises in the Unorganised Sector (NCEUS)[1]. Based on this, 'unorganised' refers to those working in the unorganised sector or households, excluding regular workers with social security benefits provided by the employers and the workers in the formal sector without any employment and social security benefits provided by the employers formed the basis for estimating the unorganised or informal sector in its reports. To identify commuters from the informal sectors in Bengaluru, this study has used the criteria used by NCEUS and collected primary data from the field. For the informal or unorganised sector, this study has collected data from the construction, transport, trade, services and manufacturing sectors. In construction, we collected data from workers who are engaged with constructing buildings and houses in the selected area/location in the city. With respect to trade, we were able to find respondents in petty shop owners, street fruit and vegetable vendors, hotel servants and cleaners. In manufacturing, we identified informal workers such as tailors and so forth. The major areas chosen for the informal sectors are Kengeri and Kanakapura Road. The details of the areas chosen for the informal sector and samples from the respective areas are given in Table 1.

Methodology

By using the appropriate methods as discussed above and below, we have chosen various 'clusters' (not census wards) across Bengaluru (Map 2), to cover industry, trade and commerce, government department, IT and informal sectors in the city, sampling from geographical areas across the metropolitan area.

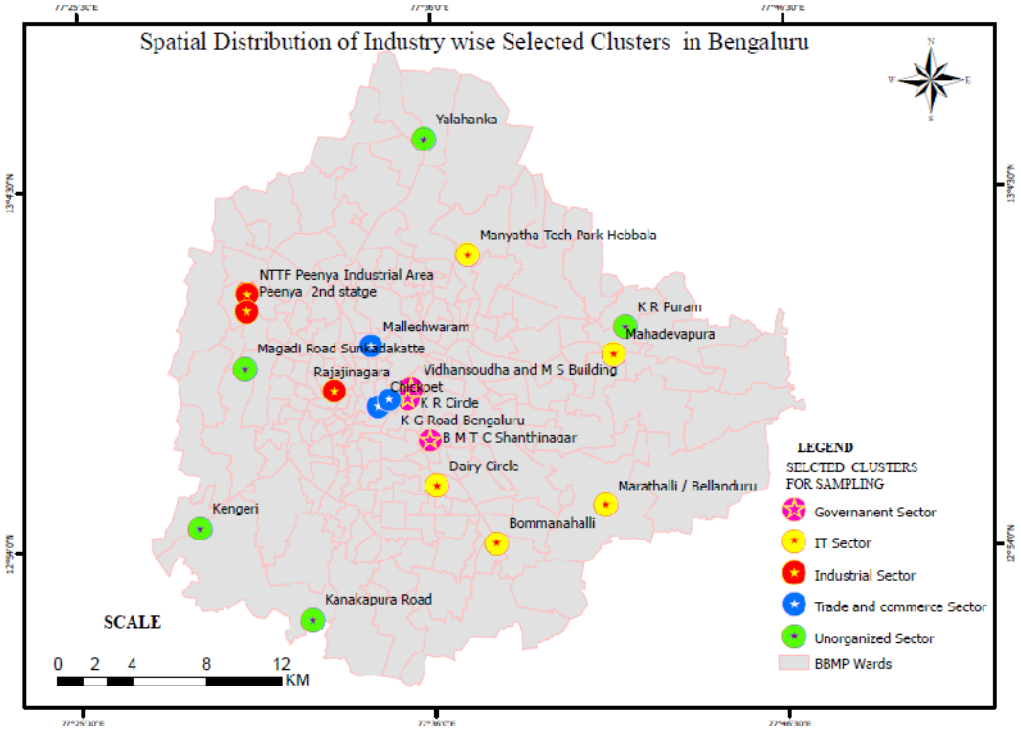
Snowball or Chain-referral Sampling

The chain referral sampling relies on a method by which one respondent led the researchers to the next one, the 2nd respondent referred the researcher to the 3rd respondent, and so forth. The chain-referral method was also helpful to ensure the randomness of the samples, because while collecting data from

[1] The NCEUS does not distinguish unorganised from the informal and these terms are used interchangeably in this paper also.

primary survey, people not only referred to their friends and colleagues from their own organization /office, but also referred to other organizations. This helps us to collect rich data from field irrespective of their age, class caste, education and gender etc. For purposes of this study, a structured questionnaire was used for which data was collected in person from field.[2] The study conducted primary surveys of 470 commuters from various clusters, and adopted snowball/chain-referral sampling techniques to collect data from various work places. This method is convenient to select respondents and to get accurate data through chain-referral sampling, which is more helpful for objectives of the study. The following section will give a brief account of the distribution of selected clusters and areas across Bengaluru.

Map 2: Spatial Distribution of Location Map of Selected Clusters in Bengaluru (BBMP)



Source: BBMP maps, Google and Authors' compilation.

[2] This is available from the authors upon request.

Table 1: Distribution of Selected Clusters and Areas across Bengaluru

SL No	Sectors	Area/ Location	Address	No of Sampling	Total
1	Government Sector	Karnataka High Court	Dr B R Ambedkar Veedhi, Bengaluru 560001	1	**100**
		Vidhana Soudha & L H	L H Office, Dr B R Ambedkar Veedhi, Bengaluru 560001	15	
		M S Building and K R Circle	KEA Planning Department, Dr B R Ambedkar Veedhi, Bengaluru 560001	31	
		Karnataka Lokayuktha Office and Department of Public Instruction	Dr B R Ambedkar Veedhi, K R Circle, Bengaluru 560001		
		BMTC Office, Shanthi Nagar	BMTC Office, Shanthi Nagar, Bengaluru	53	
2	I T Sector	K R Puram	EM Ware Technology Pvt Ltd Mahadevapura, K R Puram	22	**100**
		Dairy Circle	Think and Learn Pvt Ltd, Dairy Circle, Bengaluru	12	
		Electronic City/ Bommanahalli	ICICI Bank Bommanahalli Bengaluru	11	
		Marathalli / Bellanduru	J P Morgan, Marathalli, Bengaluru	8	
		Manyata Tech Park, Hebbal	Cognizant, CTS, Manyata Tech Park, Hebbal	47	
3	Industrial Sector	NTTF, Peenya Industrial Area	NTTF, Peenya 2nd Stage , Peenya Industrial Area	22	**100**
		Brindavana, Peenya 14th Cross	IPA Pvt Ltd	12	
		G2G Engineering Pvt Ltd, Peenya 2nd stage	G2G Engineering Pvt Ltd	27	
		Rajaji Nagar West of Chord Road	Fbb Big Bazaar and Giriyas	39	
4	Trade and Commerce Sector	Venkateshwara Textiles	Venkateshwara textiles, K G Road, Bengaluru	11	**100**
		Kuberan Silk, Chickpete	Kuberan Silk, Chickpete, Chickpete, Circle, Bengaluru	51	
		Sudarshan Silks, Chickpete	Sudarshan Silks, Chickpete Circle, Bengaluru		
		Indian Silk Society, Nakoda Silks and Sarees and Ajanta Complex Chickpete	Chickpete Circle, Bengaluru		
		Reliance Trend, Malleshwaram	4th Main Road , 8th Main Road, Malleshwaram, Bengaluru 560003	13	
		Varamahalakshmi Silk, Malleshwaram	3rd Main Road, Margosa Road, Malleshwaram, Bengaluru 560003	3	
		Kamakshi Silk, Malleshwaram	3rd Main Road , Margosa Road, Malleshwaram, Bengaluru 560003	7	
		Pai International, Malleshwaram	3rd Main Road, 8th Cross, Margosa Road, Malleshwaram, Bengaluru 560003	15	
5	Informal Sectors	Yelahanka	Yelahanka Old Town and Puttenahalli Bengaluru	19	**70**
		K R Puram	K R Puram near BMTC Bus Stop and ITI Depot	15	
		Kengeri	Kengeri TTMC Bus Stop, Bengaluru	11	
		Magadi Road	Sunkadakatte Bus Stop, Bengaluru	11	
		Kanakapura	Kanakapura Road, Gubbalala and Judicial Layout	14	
TOTAL				**470**	**470**

Source: BBMP maps, Google and Authors' compilation.

Findings of Commuters' Surveys in Bengaluru

The results of the primary surveys which are presented here were collected from respondents in person at their workplaces in the various sectors as given in Table 1. The results reported are limited to the 470 respondents who completed the survey.[3]

Socio-demographic and Economic Characteristics of Commuters

In the sample, two-thirds were male and one-third were female respondents. When we studied the age group from the selected sample, a majority, two-thirds of commuters, were in the 21 to 35 years age group, 17 per cent of commuters were in the 36 to 50 years from the sample and 7 per cent of commuters each belonged to below 20 years and 51 and above years.

The educational status of the commuters was that a majority, almost 47 per cent of commuters, were graduate, indeed 16 per cent were post graduate, followed by high school and pre-university (14 and 12 per cent respectively).

In terms of marital status, half were married; 48 per cent were unmarried from the selected commuter respondents. The remaining 2 per cent were widowed, divorced or separated.

A majority of respondents (92 per cent) were Hindu. In terms of social group, more than half (56 per cent) belonged to the general castes, 25 per cent belonged to Other Backward Class, 12 per cent were Scheduled Caste, and a smaller proportion, 4 per cent were Scheduled Tribes.

In terms of occupation, 38 per cent of commuters were in wholesale and retail trade, 15 per cent of commuters in financial intermediation, public administration and defence; compulsory social security accounted for almost 13 per cent. These three types of occupations covered 66 per cent of sampled commuters in the city. Transportation, storage and communication occupations, those in which ICT is included, constituted 9 per cent of the sample of commuters.

In terms of seniority at work, it was found that 9 per cent of respondents were working in senior level positions[4] while nearly half of respondents were working at the mid level.[5] Approximately 39 per cent of respondents were entry level employees in various sectors across the BBMP area.[6] Summarising, overall, 91 per cent of the respondents were mid or entry level employees across various sectors and rest were senior level employees in the city.

With respect to vehicular status, it was observed that 46 per cent of respondents owned a vehicle; still a larger part of the sample, 54 per cent, didn't own personal vehicles. In terms of the type

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[3] In the present study, a total of 500 respondents were surveyed, but after the removal of outliers, we were left with 470 and results are based on the 470respondents only.

[4] Here were included designations such as Assistant General Manager Accounts, Assistant General Manager Engineer, Assistant Director, Team Manager, Deputy Director and Manager, HR Manager, Project Manager, Sales Manager, Sr Judgment Writer and Purchase Manager.

[5] Here were designations such as Account Executive, Supervisor, Assistant Engineer, Assistant Admin Officer, Assistant HR, Business Associate, Business Development Associate, Cashier, Category Head, Executive Engineer, Floor Manager, Gazetted Assistant, Operational Analyst, Police Head Constable, Senior Process Executive, Reporter KLC and Traffic Inspector.

[6] Entry level employee designations include positions such as Sales Executive, Assistant Store Keeper, Construction Worker, Carpenter, Security Guard, Service Boy, Trainee and Car Driver and so on and so forth.

of vehicle owned by the respondents, a majority (78 per cent) of them owned a two-wheeler, followed by car (12 per cent).

Nearly all (99 per cent) of commuters were working full time; this shows the need for transportation options for commuting to work in the city.

Table 2 gives the descriptive statistics on the income, commuting distance, time and monthly expenditure on commute to work of the respondents.

When we studied the monthly income of the respondents from the selected sample, the range was from Rs 2,000 to Rs 96,000 per month. Table 2 gives an overview of the monthly income of the respondents. The average monthly income is Rs 22,428 from the selected sample, consistent with the income reported by Sridhar *et al* (2018) for Bengaluru. Further, we find this income is consistent with Karnataka's urban per capita income, which was Rs19,018 for 2015 (based on CSO data for Karnataka, divided by its urban population). These estimates of income for the first income earner are also consistent with that reported by the Economic Survey of Karnataka, 2015-16, where the monthly per capita income is Rs 12,149, with Rs 14,610 being the regular monthly wage income for urban Karnataka.

Table 2: Descriptive Statistics on Selected Variables of Commuters

Variables	Number of Respondents	No response	Minimum	Maximum	Mean	Std. Deviation
Monthly Income in Rs.	465	5	2000	96000	22,428	14285.92
Monthly Expenditure on Commute to Work in Rs.	426	44	300	15000	2589.22	1582.085
Actual Commuting Distance to Work in km (One-way)	470	0	1	45	10.84	7.72
Actual Commuting Time to Work in Minutes (One-way)	470	0	5	150	42.45	28.59
Actual commuting Cost in Rs. (One-way)	384	85	0	150	34.23	22.87

Source: Primary field survey 2018 and Authors' analysis.

Expenditure on commute to work also varies within the sample, because commuters are located at varying distances from their work place, spending anywhere from Rs 300 to Rs 15,000 monthly for their round trip commute to work. The average commuting monthly cost (round trip from home-work-home) is Rs 2,589.22. It is interesting to note that ten (44 respondents) per cent of commuters did not incur any commuting costs as they walked or used their bicycle for the commute to work.

The actual distance to reach the workplace (table 2) of respondents is on average 10.84 km travelled by commuters from selected samples, this is consistent with evidence reported from Sridhar *et al* (2015 and 2018). The WRI reports something like close to 15 kms of one-way commute to work in Bengaluru (Table 4).

The actual time taken by commuters to reach their workplace (table 2) is 42.45 minutes one-way. When we consider that the one-way travel time to work in Bengaluru was only 40 minutes in 2001 (Savage and Dasgupta, 2006), the higher average travel time to work now implies an insignificant reduction in the city's effective labour market since 2001. Bertaud (2014) reported that most cities of

the world report a one-way travel time of about 30 minutes to work. Table 2 gives the descriptive statistics on the actual time taken in minutes for commute to work of the respondents from this study.

The actual commute cost to reach the workplace is Rs 34.23 per one-way trip. The evidence from WRI (2014) is Rs 100-300 range and from Sridhar *et al* (2018) is Rs 33.39 round trip (see table 2). Table 4 summarises various studies and research reports of commute to work and the details with respect to Bengaluru, along with the findings from this study.

Table 3 provides an overview of commuters who travel during peak and non-peak hours[7] using various modes in the city from this study. The government sector has 95 per cent of commuters who travel to work during peak hours and in trade & commerce sector, more than 96 per cent of commuters travel during the peak hours. These two (government and trade & commerce) sectors have the highest proportion of commuters who travel during the peak hours. These sectors are followed by the industrial sector with 66 per cent peak commuters, with only 10 per cent of commuters from IT and 6 per cent of informal sector commuters travelling during the peak hours using various modes in the city. Taking into account all the sectors, more than 70 per cent of commuters travel during the peak hours and 30 per cent of commuters travel during the non-peak hours in the city. This should indicate the reasons for the long commuting time in the city, as more and more commuters are travelling during the same time (peak hours) which leads to congestion due to more number of vehicles on the road and this is also tested through regression analysis later.

Table 3: Sector-wise Distribution of Commuters during Peak and Non-peak hours (One-way, morning)

Sectors	Commuting during peak hours % (Number of respondents) (8 to 11 am)	Commuting during non-peak hours % (Number of respondents) (Rest of the day)	Total % (Number of respondents)
Government Sectors	20.21 (95)	1.06 (5)	21.28 (100)
IT Sector	9.57 (45)	11.70 (55)	21.28 (100)
Industrial Sectors	14.04 (66)	7.23 (34)	21.28 (100)
Trade and Commerce	20.43 (96)	0.85 (4)	21.28 (100)
Informal Sectors	6.17 (29)	8.72 (41)	14.89 (70)
Total	70.43 (331)	29.57 (139)	100 (470)

Source: Primary field survey 2018 and authors' analysis.

[7] Peak hours are defined as 8 am to 11 am in the morning and non peak hours are before 8am and after 11am of the morning time. For convenience, we assumed that those who commute during peak hours in the morning also commuted during peak hours in the evening. This may or may not be the case.

Table 4: Summary of Studies on Commute to Work, Bengaluru

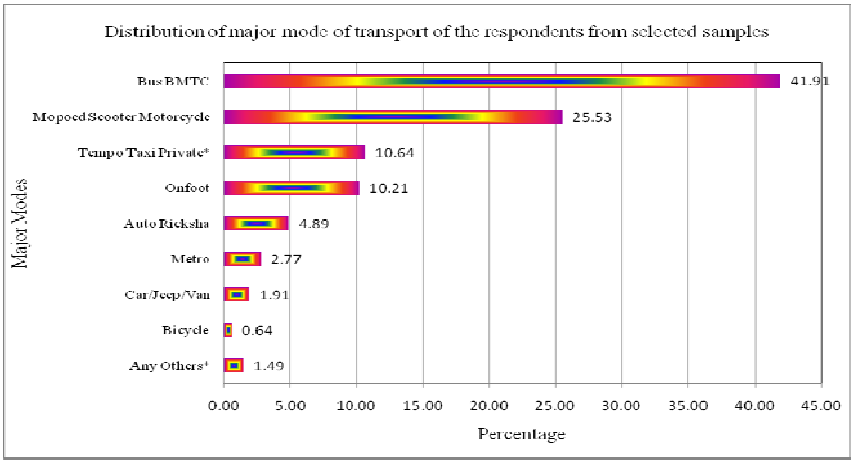
SL NO	Studies	Survey Type	Year	Commuting Time (in minutes)	Commuting Distance (in Kms)	Commuting Cost (in Rs)	Remarks
1	WRI India 2014	Selected gated communities in Bengaluru HH Survey	2014	Range 30-90	Average 15	100-300	Commute to work daily (Private and public)
2	ISEC-(CRUA): A Pilot Study from Nagarabhavi in Bengaluru	Household survey: A Pilot Study from Nagarabhavi	2015	42	10.4	NA	Based on 200 respondents in Nagarabhavi ward
3	Move Insync Report 2016	Five million shared rides in 15 cities which include Bengaluru	2016	Average 47	Average 16.8	NA	On average, a Bengalurean spends 94 mins per day on the road for office commute, which is 7% of his life
4	ISEC-ICSSR study Bengaluru City Survey 2017	Household survey	2017	29	7.71 One-way	33.39 Round trip	Based on 1,500 respondents throughout Bengaluru
5	ISEC-Azim Premji University Study	Household survey	2018	27	5.54 One-way	28.40 Round trip	Based on 1,200 respondents throughout Bengaluru
6	Present study Commute to work survey 2018	Workplace survey 2018	2018	Average 42.45 (One-way)	Average 10.84 (One-way)	Average 34.23 (One-way)	Based on work location survey (470 respondents) throughout Bengaluru with various cluster/ Sectors

Source: Various studies, reports and Authors' compilation.

Commuting Modes

The primary surveys for this study indicated that 41.91 per cent of commuters are using public transport, the BMTC, to commute to work in Bengaluru. The Census 2011 on transport modes shows for Bengaluru that a smaller percentage than indicated by this study, approximately one-fourth of urban ('other') commuters used the bus. Secondly, Bengaluru has the second highest number of two-wheelers as per data.gov.in, interestingly our survey results also show that the moped, scooter/motorcycle was used as second major mode (25.53 per cent) of transportation in the city to get to work. According to our survey, tempo taxi (private) is the third most used mode of transport for commuters to get to work. Interestingly, more than 10 per cent of commuters were walking to reach their workplace, which calls for serious attention towards providing better pedestrian infrastructure facility to the commuters in the city. Figure 1 gives a summary of the modes of transportation used by commuters to get to work. Table 5 gives the glimpse of transportation modes grouped under various categories (public, private/personal modes and (NMT) non motorised transport) along with their respective usage in the city.

Figure 1: Status of Modes of Transportation and Respective Percentage of Commuters for the Selected Samples from Bengaluru



Source: Primary field survey 2018 and authors' analysis.

Tempo/ Taxi (Private)* includes taxi (Ola and Uber)

Any others* includes train, pooling car, auto etc.

Table 5: Details of Transportation Groups and their Respective Percentages for Selected Samples from Bengaluru

Mode of transportation group	Commuters	Percentage
NMT Modes*	51	10.85
Personal/Private Modes*	183	38.94
Public Modes*	236	50.21
Total	470	100

Source: Primary field survey 2018 and authors' analysis.

*NMT Modes includes commuting on foot and Bicycle

*Personal Modes includes Moped/Scooter/Motorcycle, Car/Jeep/Van, Private Taxi and Pooling Car, Auto etc,

*Public Modes includes BMTC, Metro and Train, Autoricksha and Taxi, Ola and Uber.

The next section provides the origin and destinations of commuters using the rich primary data for Bengaluru's intra urban commuters.

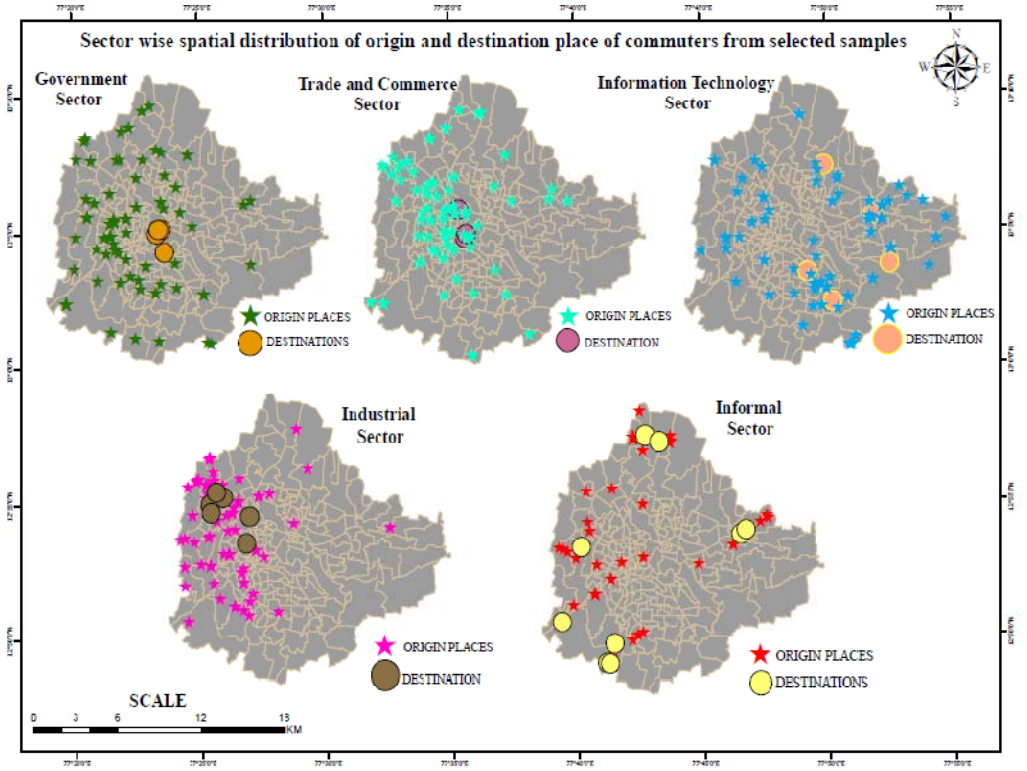
Where do the Commuters Come From and Where do they Go to Work?

The origin and destination of the commuter is one of the important aspects, because commuting time and distances depend on the distribution of residence and workplaces. As discussed earlier, as per this study, Bengaluru has seen a reduction, although insignificant, in its effective labour market since 2001-2018, which means the city's commuters are travelling less distances and taking more commuting time to reach the workplace. So to understand the commuting pattern of Bengaluru with origins and destinations of the commuters is important.

Map 3 gives the sector-wise spatial distribution of origin and destination place of commuters. The top left corner of Map 3 shows the details of origin (home) and destination (workplace) of the

government sector employees who have completed the survey. Similarly, other maps in Map 3 show the spatial distribution of the origin and destination of other sector commuters.

Map 3: Sector-wise Composite Map for Spatial Distribution of Origin and Destination Place of Commuters from Selected Samples



Source: Primary field survey 2018 and authors' analysis.

When we studied the commuters from the government sector, we find that they live all over Bengaluru and commute towards the central part of the city, where government offices are located, consistent with what the standard urban model predicts and the assumptions of the methodology and choice of clusters in this study. The major government sector destinations, as discussed earlier, are Vidhana Soudha, M S Building, Karnataka High Court, K R Circle and Shanthi Nagar (BMTC and KSRTC) offices which were chosen for the survey and these destinations are given in Map 3 which are almost in the city centre as shown in the map. When we study the origin and destinations of the trade and commerce sector, we find that a majority of the commuters live all over the metropolitan area and commute towards commercial places like Chickpete, K G Road and Malleshwaram, which are the chosen clusters for representing retail activity.

When it comes to the Information Technology (IT) sector, the workplaces are concentrated in the eastern areas such as Dairy Circle, Koramangala, Bommanahalli, Marathahalli, K R Puram and Hebbal, as discussed in the section on sampling and choice of clusters. Commuters living across the entire metropolitan area are commuting to reach the destination of the IT sectors (see Map 3 top right corner). Map 3 (bottom left corner), shows the origin and destination. Most of the employees who work

in industrial sector live in the west and southern parts of the city, and commute to their workplace in the west, implying less commuting time. Lastly, the informal sector commuters' origin and destination are given in Map 3 (bottom centre), which shows the concentration of informal workplaces at the city's periphery. We generally expect the informal sector to have shorter commuting distance, given their relatively less skilled work, compared to other sector commuters. Informal sector commuters (domestic maids, vendors, drivers, cooks, construction workers and so on) find jobs nearby or stay nearer to where the jobs are available and in rare cases, they travel long distances. It should be remembered that where the various industries are located are due to the sampling. For instance, government offices have been sampled in this study in the central location only, whereas government offices may be located in the peripheral areas as well.

The following section describes the determinants of commuting time based on responses from the selected sample.

Determinants of Commuting Time in Bengaluru

The empirical model of commuting time uses commuters' data (obtained from the primary survey of 470 respondents) to estimate the determinants of commuting time. The purpose is to examine how individual commuting time varies across socio-economic and demographic characteristics. The regression analysis hypothesises that socio-economic and demographic variables like age, education, sex, marital status, commuting distance, time of day (if peak or off-peak) and income determine the commuting time. The expectations are that the more educated, those that are married, and those with higher incomes, would have longer commutes, compared with that of the less educated, single and those with lower incomes respectively. The expectation is also that those travelling during peak hours and those travelling longer distances will have longer commutes, other things remaining constant. Equation 1 presents the econometrically identified model determining commuting time.

Commuting time $=\alpha_0 + \alpha_1$ Education$+ \alpha_2$ Age $+ \alpha_3$ Sex $+\alpha_4$ Marital status $+ \alpha_5$ Income $+ \alpha_6$ Mode $+ \alpha_7$ Distance $+ \alpha_8$ Peak hours$_i + e_i$----------[1].

Table 6 provides the details of variables, codes and full form of the variables which are used in the regression analyses. The following section discusses the determinants of commuting time for Bengaluru's commuters; the regression results shows that all the variables are not statistically significant in determining commute time. The inclusion of all relevant variables is needed to minimize errors arising from any omitted variable bias. Further one has to note that the regression method is also not a step wise regression to include only statistically significant variables in a stepwise manner. We compute the correlation matrix, to check the robustness of the variables and re-estimated the regression model accordingly.

Regression results (model 1 estimated and results shown in Table 7) show that sex, marital status, peak hour commute and actual commuting distance in km coefficients are highly statistically significant in influencing the commute time. Specifically, we find that men have longer commute times when compared with that of women. These are consistent with the findings from other studies. Lee and McDonald (2002), taking the case of Seoul in their paper, also reported similar results. Giuliano (1998)

reported results that women workers in Los Angeles had commuting time that was 3.2 minutes shorter in 1990.

Table 6: Details of Variables Included in the Regression Analysis for Commute to Work

Sl No	Determinants	Codes	Full form
1	Age in Years	Actual age in years	
2	Education	Years_of_Schooling_0	Illiterate
		Years of Schooling_12	Primary School, Middle School, High School,
		Years of Schooling_14	Pre-University
		Years of Schooling_17	Graduate
		Years of Schooling_25	Post- Graduate and PhD
3	Sex	Sex_1_male	Male
		Sex_0_female	Female
4	Marital Status	MaritalStatus_0	Unmarried
		MaritalStatus_1	Married
5	Major Commuting Modes	M_Transport_1	On foot
		M_Transport_2	Bicycle
		M_Transport_3	Moped/Scooter/Motor Cycle
		M_Transport_4	Car /Jeep /Van
		M_Transport_5	Bus BMTC
		M_Transport_6	Metro
		M_Transport_7	Autoricksha
		M_Transport_8	Tempo/ Taxi (Private)
		M_Transport_9	Taxi Ola and Uber
		M_Transport_10	Train
		M_Transport_11	Pooling Car, Auto etc
		M_Transport_12	Any others
6	Peak or Non Peak hours	Peak Hours1	Commuting during peak hours
		Non Peak Hours0	Commuting during non-peak hours
7	Income	Actual Monthly Income	
8	Distance	Actual Commuting Distance	
9	Time	Actual Commuting Time	

Source: Primary field survey 2018 and authors' analysis

Table 7 shows that those that are married have longer commute times when compared to that of singles. This is reasonable and implies that when one is married, they have to take into account other considerations, such as their spouse's employment location, in their household location decision. It could also be the case that those that are married have their own house, and hence could endure long commutes for living there. Obviously, the distance to the job is the one that has the most positive impact on commute time. The longer the distance, the longer the commute, and vice versa, as one would expect. The peak hour commuters have an extra 6 minutes of commute to work, holding other things constant. The model in equation 1 is a reasonably good fit of commute time as the variables included explain more than half of the variation.

In our regression results, some variables (education, age, monthly income and modes) are not statistically significant in determining commute time. It is possible that education is insignificant because while some of the more educated commuters may travel long distance, some of the higher educated commute a short distance. So this will reduce the significance level of the variable given its standard error will become large. Monthly income likely does not determine the commuting time, for the same reasons that education does not.

Similarly, while age is included as a control in the regression, it may not be a good indicator for other factors like skills, experience and higher level of education which could influence the commute time more.

With respect to commuting mode, in our regression analysis, we have considered only major modes for the regression and we have not grouped the modes based on the speed. For example if a person uses metro to commute to work every day his /her commuting time will be lesser than those who are walking, or using the bicycle, auto and bus etc to reach the work place. It is possible that if the commuting modes had been grouped based on speed, then this variable may have had a statistically significant effect on commute time.

Dependent Variable: Commuting Time (Actual time in minutes).

Table 7: Regression Results of Commuting Time

Model Coefficients	**Coefficients**			
Variables	**B**	**Std. Error**	**t**	**Sig.**
(Constant)	-5.185	5.665	-.915	.361
Education	.223	.700	.319	.750
Age (in year)	.010	.120	.085	.932
Sex	3.316*	1.988	1.668	.096
Marital Status	4.545**	2.180	2.085	.038
Monthly Income	.219	.772	.284	.776
Modes	.109	.476	.230	.818
Actual Commuting Distance in KM	2.709***	.130	20.860	.000
Commuting Peak and non Peak hours	6.274***	2.011	3.120	.002
	R	R Squared	Std. Error of the Estimate	
	0.74	0.55	19.33	

*Statistically significant at the 10 per cent level.

**Statistically significant at the 5 per cent level.

***Statistically significant at the 1 per cent level.

Source: Primary field survey 2018 and authors' analysis.

We predicted travel time to work, based on the model estimated and shown in Table 7 (Appendix table 1). We found that more than 30 per cent of commuters travelled more than the commuting time predicted by the model presented in Table 7. When we analysed the socio economic characteristics (Appendix table 1) of the commuters that were travelling more than the predicted

commuting time, we found 27 per cent of commuters were from the government sector - these are likely using public transport as that mode takes more time with frequent stops. This is followed by trade and commerce and IT sector wherein respectively 21 and 20 per cent of commuters' actual commuting time was greater than that predicted by the model here. While the trade and commerce workers are those who are dependent on public transport modes (such as the BMTC bus) which increase the travel time, IT sector workers likely live far away from their workplace, which increases their travel time.

We examined and found indeed that a majority of BMTC commuters were travelling during the peak hours, of which more than 45 per cent were commuting more than the time predicted by the model here. These findings indicate the need for improvement in public transportation and its related infrastructure facilities to provide sustainable means of mode of public transport for the intra-urban commuters in the city.

Conclusions and Policy Implications

This study has used primary surveys of intra-urban commuters at the workplace to understand the determinants of commuting time in Bengaluru, with this being one of the few papers to look at not only the commuting time, but also their determinants. Further, this study provides the spatial distribution of origin and destinations by sector (which is fixed by sampling) for a large Indian city which is characterised by severe traffic congestion. At the intra-urban commuter level, we find gender and marital status are statistically significant determinants for commuting time for the commuters. We find that actual commuting distance is positive and a statistically significant determinant of commute time for intra-urban commuters. These results are supported by other studies such as Lee and McDonald (2002), Giuliano (1998) and Johnston-Anumonwo (1992) in the context of other cities of the world.

In Bengaluru, we find that the one-way average commute time to work is 42.45 minutes to cover an average distance of 10.84 km. This shows that Bengaluru's effective labour market decreased during 2001-18, quite in contrast to what Sridhar (2017b) and Sridhar *et al* (2018) reported. However, those studies were based on household surveys, whereas this study uses data from the workplace. Nonetheless, as Bertaud (2014) reported, these other studies report a travel time of less than 30 minutes one-way to work; Nayka and Sridhar (2019), using secondary data on travel time across cities, reported that Chennai's travel time is significantly lower than that of other cities, which testifies to its relatively larger labour market, even while nearly 46% of its jobs are suburbanised, when compared with cities such as Bengaluru.

Hence the immediate need for an Indian city like Bengaluru is to improve the public transport, and transport speed in the city, to ensure that its effective labour market is large. Affordable and convenient means of transport seems to be an imperative in Bengaluru, given that a large number of commuters (10.43 per cent) travel by foot for very long distances.

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Appendix Table 1: Summary of socio economic characteristics of selected commuters for whom actual commuting time was more than the predicted commuting time

Sectors	Number of respondents	Percentage
Govt Sector	56	27.45
T and C Sectors	44	21.57
IT Sector	42	20.59
Industrial Sector	31	15.20
Informal Sector	31	15.20
Total	204	100
Education	Number of respondents	Percentage
Illiterate	11	5.39
Primary School	2	0.98
Middle School	3	1.47
High School	36	17.65
Pre-University	26	12.75
Graduate	87	42.65
Post- Graduate	38	18.63
PhD	1	0.49
Total	204	100
Actual Commuting Time	Number of respondents	Percentage
Less than 30 Minutes	61	29.90
31 to 45 Minutes	37	18.14
46 to 60 Minutes	42	20.59
61 to 90 Minutes	43	21.08
91 & above Minutes	21	10.29
Total	204	100

Source: Primary field survey 2018 and author's analysis

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