ACCESSIBILITY AND CONNECTIVITY CHALLENGES OF MASS RAPID TRANSIT IN KUALA LUMPUR, MALAYSIA

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Abstract

Mass Rapid Transit (MRT) is a modern public transportation mode, involving highway lanes or rights-of-way dedicated exclusively to specially designed buses. MRT is one of the most effective ways to reduce the use of private vehicles for daily travel in big cities. The success of MRT, however, depends on the reliability of service, the speed at which vehicles can travel, and their overall attractiveness to passengers. This study of the introduction of MRT in Kuala Lumpur, Malaysia, makes clear that the level of accessibility and connectivity of MRT are vital.

The study investigates how accessibility and connectivity affect the "ride experience" of MRT users. Survey results suggest that:

1) Feeder bus services in residential areas are crucial;
2) Lack of connection with other public transport modes can undermine interest in switching to MRT;
3) Multi-mode fare passes that link MRT to other transit connections are necessary;
4) Limited park and ride space and bicycle parking at MRT stations, along with the cost of parking, can inhibit MRT use; and
5) The availability of commercial services like shopping in and around MRT stations can adversely affect potential MRT riders' decision to use MRT.

Results show that the average number of trips per MRT user depends primarily on the accessibility and connectivity of MRT stations. The paper offers policy recommendations aimed at encouraging more riders to reduce their reliance on private vehicles through increased use of MRT services.

Introduction

Traffic congestion and pollution are two significant problems that confront many urban areas in Malaysia, including the capital region of Kuala Lumpur (KL). Mass Rapid Transit (MRT) can increase rail transportation opportunities by providing a premium quality service at a reasonable fare, when compared with other transport modes—an option that a significant segment of KL's population wants—and by integrating many of the existing rail networks (Fouracre, Dunkerley, and Gardner 2003). Furthermore, MRT expansion can reduce the number of travelers using private vehicles and hence alleviate the severe traffic congestion and pollution in the city.

To meet customers' needs, public transport services, especially MRT, must follow regular schedules; be safe and efficient; guarantee high-quality service; and use resources effectively. For an MRT system to achieve all of these qualities, both good *accessibility* and *connectivity* are necessary. Good accessibility facilitates the convenient use of MRT services by people with various needs and circumstances. Good connectivity provides services between users' origin and destination, and offers return trips at times that suit users' schedules.

Having recognized the potential benefits of MRT, Malaysian transportation authorities undertook the first MRT project in 2010, with the first entire Line MRT in KL beginning operations in July 2017. As with any new public transport service introduced to the public, however, the MRT in its initial stages faces challenges. The objective of this study is to investigate those challenges—particularly the challenges of accessibility and connectivity—and how they affect users' MRT experience. By documenting these challenges and offering policy implications, we hope to help developing cities improve their planning of future MRT systems.

The next section of this study provides background on the role of Mass Rapid Transit (MRT) in public transport, and its contributions to reducing congestion and pollution in cities. This is followed by a review of the importance of accessibility and connectivity for the success of an MRT system. Next is an overview of the context for MRT in Malaysia. This is followed by a summary of my research methodology. In the study's final section, I present findings and make policy recommendations.

Background: Mass Rapid Transit

What is mass rapid transit?

Mass rapid transit is defined as "modes of urban transport (both road and rail based) that carry large volumes of passengers quickly"

(Fouracre, Dunkerley, and Gardner 2003). These modes tend to be located along well-defined corridors connecting suburbs to city centers, and have reserved right-of-way for part or all of their route.

MRT systems have been categorized according to the type of technology used and their degree of segregation from traffic. MRT consists of a spectrum of modes of urban public transport that apply specific fixed-track or exclusive and separated use of a potentially common-user road track. The role and form of MRT, of course, depends on the city context: its size, income level, asset base, institutions, existing transport systems, and other cultural and behavioral factors (Rahman 2008).

MRT systems include several transport modes in both road and rail. According to Fouracre et al. (2003), the most common MRT systems include buses using dedicated rights-of-way (ROW); tramways using light, electrically powered cars on ROW; Light Rapid Transit (LRT) that employs a fully segregated and often grade-separated ROW and advanced control systems; metros using fully segregated, and grade-separated, track that may be elevated or underground. Suburban rail tends to be part of a larger rail network, often at grade but separated from road traffic.

In this study, I focus on metros, which employ very advanced control systems that allow high-frequency operations. They are also made up of multiple units of high-capacity “heavy” cars. Although metros are the most expensive type of system, they provide high levels of speed and frequency in their service. The rest of this study uses the term “MRT” to imply “metro.”

MRT’s role in public transport and contributions to reduce traffic congestion

Most cities in the developing world have very limited resources to cope with the high levels of public transport demand they experience. The selection of the most appropriate mass transit mode can be difficult, in part because there are many pressures on civic leaders to favor one system over another. Several previous studies indicate that MRT can offer a high level of energy savings and cleanliness, making it one of the most favored types of transport modes (Rahman 2008; Li 2013). MRT has been adopted in major cities around the world (e.g., Singapore, Hong Kong). Many experts believe that MRT can reduce congestion, improve quality of life through reducing pollution, and reduce fuel consumption by private vehicles (Vanany et al. 2015). In addition, many scholars also point out that MRT has other benefits such as high capacity, fast travel times and high frequency, and is designed to stop at many stations in urban centers).

MRT also provides a premium quality service at a premium fare, compared with buses. This segments the travel market, and results in "competing" bus services, which are used by lower-income travelers. The fee to ride MRT is in part determined by the competing bus services, and is designed to attract premium bus passengers who would otherwise take express/air-conditioned/guaranteed seating buses, as well as a large number of lower middle-income bus passengers. Only if it attracts multiple segments of bus ridership is the metro likely to attract the mass ridership that its high cost requires.

Apart from these benefits, an MRT system holds the potential not only to significantly leverage an existing inadequate rail network, but also to integrate existing rail networks. For all of these reasons and more, MRT is deemed as a crucial component to secure long term advances in public transport—or at least to stabilize the share of people traveling by public rather than private transport (How 1990). As a result, MRT has become one of the most popular types of public transport in developing cities around the world.

The role of MRT in reducing pollution

As noted, a crucial role of MRT is its contribution to reducing pollution in cities. Experts indicate that an efficient, comfortable transport system can convince many people leave their vehicles at home and use the MRT to commute. Building an MRT system not only help commuters avoid traffic congestion, but also helps reduce air pollution (Fox 2000). The driverless technology and well-ventilated stations located at key areas reduce commute time, and also help to decrease air pollution. Fox (2000) also states that as an MRT system replaces existing buses, it skews the traffic composition towards cleaner vehicles and reduces vehicle-kilometers traveled. Overall, MRT can have a strategic impact upon the city form, leading to a denser urban form and a more sustainable development path (Fouracre, Dunkerley, and Gardner 2003).

Empirically, Kaho et al. (2008) estimate that at current levels of use, public transit services in the United States such as MRT and commuter trains avoid emissions of at least 6.9 million metric tons of CO2 equivalent—by substituting for automobile travel and reducing traffic congestion—and possibly much more by creating more accessible land use patterns (Kaho et al. 2008). They estimate that a typical household could reduce its total greenhouse emissions by 25-30 percent by shifting from two to one vehicles, as can occur if they move from an automobile-dependent community to transit-oriented development. One study—drawing on data from the National Transit Database combined with information from the United State Department of Energy and the United

State Environmental Protection Agency—indicates that the use of public transportation offers a low-emissions alternative to driving (Hodges 2010).

Another national-level study, conducted by Kwan et al., estimates the changes in carbon dioxide (CO_2) emissions and the health co-benefits from two new mass rapid transit (MRT) lines in Greater Kuala Lumpur, Malaysia. Changes in CO_2 and air pollutant emissions were estimated from motor vehicle activity based on the travel information collected from a survey. The result reveals that MRT lines would reduce 6 percent of CO_2 equivalent emission from private motor vehicles in Greater Kuala Lumpur, and provide important health co-benefits to the population (S. C. Kwan et al. 2017).

The importance of accessibility and connectivity to MRT

Several previous works on public transport have focused on accessibility (Morris, Dumble, and Wigan 1979; Handy and Niemeier 1997; Polzin 1999; M. P. Kwan and Weber 2003; Zhu and Liu 2004; Wibowo and Olszewski 2005; Prasertsubpakij and Nitivattananon 2012; Djurhuus et al. 2014; Papaioannou and Martinez 2015) and connectivity (Guo and Wilson 2011; Hadas and Ranjitkar 2012; Mishra, Welch, and Jha 2012; Welch and Mishra 2013; Papaioannou and Martinez 2015). The review of this body of literature is composed of two parts. The first subsection offers discussion on the importance of accessibility for the development of public transport and the success of MRT in developing cities, while the second subsection covers the importance of connectivity.

Accessibility

Based on previous studies (Morris, Dumble, and Wigan 1979; Wibowo and Olszewski 2005; Papaioannou and Martinez 2015), accessibility in this context is defined as the ease with which activities may be reached from a given location by means of a particular mode of transportation.

MRT accessibility has become a major issue for authorities in many of the world's large cities, because they aspire to shape the future through implementation of efficient mass transit systems. Several studies stress that accessibility plays an important role with respect to the success of public transportation and MRT systems. Papaioannoua and Martinez (2015) noted that one of the key factors affecting public transport mode choice of users is accessibility. Accessibility represents the potential of the user to perform his/her activities.

Accessibility can be considered from two perspectives. The first is proximity relative to the points of access to the MRT system—both at origin and destination—which has been proven to be a key deciding factor in the modal choice process (Givoni and Rietveld 2007; Moniruzzaman and Páez 2012). The second is the ease of displacement considered in relation to cost (of time or tariff) to reach the desired activities. This is associated with the *density*, *diversity*, and *design* of the built environment, both at trip origin and destination—sometimes referred to as the “3Ds” (Cervero and Kockelman 1997).

Prasertsubpakij and Nitivattananon (2012) found that providing suitable accessibility increased the use of MRT systems in Bangkok, because certain segments of the population (e.g. women, the elderly and disabled people) were able to take MRT easily (Prasertsubpakij and Nitivattananon 2012). These authors note that women—who tend to have less access to MRT—are likely to have multiple purposes associated with their trips. Good accessibility of a MRT system can help them achieve those multiple objectives.

Many studies (Geertman and Ritsema Van Eck 1995; Handy and Niemeier 1997; Zhu and Liu 2004) use a potential gravity model to delineate accessibility into two elements: the *activity* element (spatial distribution and attraction of various activities), and the *transportation* element (travel distance, time, or cost to reach specific sites by certain transportation modes) (Figure 1). The greater accessibility is, the less time and money are spent in travel, and the more activities that can be reached in a given amount of time and within a certain budget (Zhu and Liu 2004; Prasertsubpakij and Nitivattananon 2012). Hence, it is argued that maximizing the accessibility of MRT system is one of the fundamental goals of transportation planning and urban development—which in turn facilitates the development and the success of MRT projects.

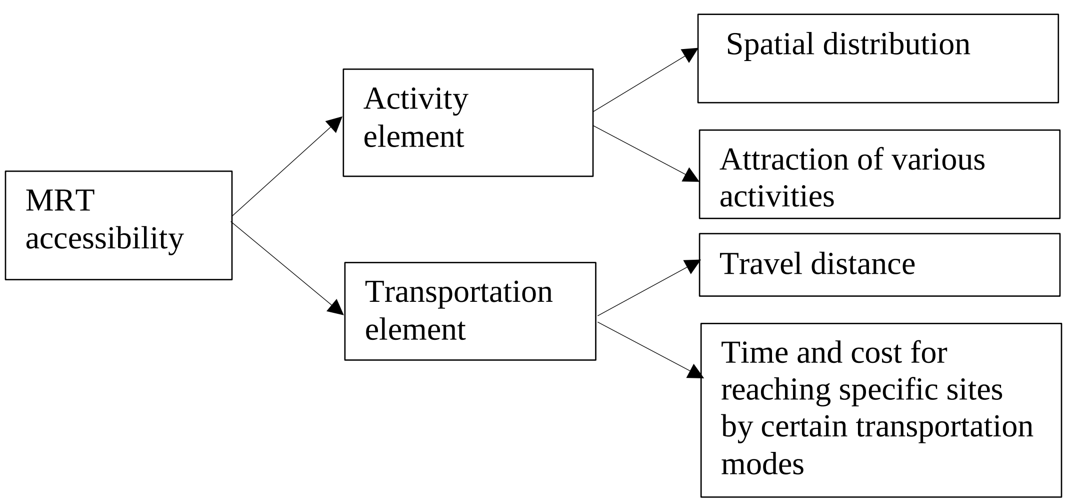

Figure 1. Potential gravity model[1]

Similarly, Soltani et al. (2012) point out that accessibility is increasingly recognized as a key element of a high quality, efficient, and sustainable public transport system. According to Turcotte (2005), inaccessibility to the built physical environment is one of the significant barriers to full participation of persons with disabilities in society (Turcotte 2005)—for example, when disabled people face challenges and difficulties in using MRT service.

"Accessibility" is also defined by the attractiveness of individual destinations served by MRT. Individual origins may also be weighted by their socioeconomic factors, such as the number of residents, age, and social /economic status. These factors help determine the potential demand for particular activities. Most accessibility measures assume that accessibility between origins and destinations is directly proportional to the associated demand and attraction, and inversely proportional to the distance or time or cost for traveling between them. Over the last four decades, various accessibility measures have been developed and used to evaluate the performance of urban transportation systems, and serve as a basis for making trade-offs between land use and transportation policies (Davidson 1977; Páez, Scott, and Morency 2012; Moniruzzaman and Páez 2012). Zhu and Liu (2012) indicate that maximizing accessibility becomes an important agenda in urban transportation planning, and creates new services and activities, which in turn persuades more people to use metros.

In sum, addressing the multiple dimensions of accessibility contributes significantly to the success of MRT projects.

Connectivity

Another issue that greatly influences the success of public transport, including MRT, is connectivity (Beimborn, Greenwald, and Jin 2003; A. (Avi) Ceder and Teh 2010; Papaioannou and Martinez 2015). Connectivity is deemed to be good when service exists between users' origin and destination, and provides return trips at times that match the users' schedule. Connectivity also involves customer's ease of transferring from one public transit system (such as MRT) to another (Associates et al. 2006). Factors like long travel time and high number of transfers—determined by the design of the network—sometimes discourage potential users from choosing public transport (Guo and Wilson 2011). Other aspects, including the route of the public transport service and the travelling distance between origin and destination, affect the speed of public transport (Papaioannou and Martinez 2015; Welch and Mishra 2013; Mishra, Welch, and Jha 2012). Private vehicles can follow direct routes to their destinations and—in many cases—achieve higher speeds, and may dissuade potential users from choosing public transport (Beimborn, Greenwald, and Jin 2003).

To sum up: Many scholars (Beimborn, Greenwald, and Jin 2003; A. (Avi) Ceder and Teh 2010) argue that for MRT to prevail in the competition for users, the system must good connectivity. Good connectivity is defined as a convenient and seamless system that reduces travel times, provides reliable connections, and ensures easy and safe transfers.

Conversely, poor connections can cause passengers to stop using the MRT service (A. Ceder, Net, and Coriat 2009; Hadas and Ranjitkar 2012; Papaioannou and Martinez 2015). When connectivity is poor, trips are lengthy and costly. In addition, weak segments of the public transport connectivity network will experience increased congestion and passenger accumulation at specific stations and stops, resulting in delays and passenger frustration (A. Ceder and Perera 2014). For these reasons and more, Ceder et al. (2009) state that improving connectivity is a vital task in transit operations planning.

Public transport context and MRT system in Malaysia

Kuala Lumpur (KL), the capital city of Malaysia, is ranked as the second-most competitive global city in Southeast Asia by the Economist Intelligence Unit. The city is a center for the country's finance, insurance, real estate, and media industries. It is Malaysia's most populous city, with (in 2017) 7 million residents within its 243 square kilometers—a population total that is projected to increase to 20 million by 2020. Greater Kuala Lumpur (also known as the Klang Valley) where the greatest percentage of Malaysia's population resides, contributes 30 percent of the national gross domestic product (GDP) (S. C. Kwan et al. 2017).

Given the city's and region's economic importance, and in light of its growing population density, an adequate public transport system is key. Today's system—intended, in part, to minimize heavy traffic congestion in KL—includes a variety of services such as rapid bus transport (BRT), light rail transit (LRT), one monorail line, commuter rail (Keretapi Tanah Melayu, or KTM), an airport rail link, and an emerging MRT network. The MRT project is considered a crucial component of the Greater Kuala Lumpur National Key Economic Area, and the largest infrastructure project in the country. Line One of the MRT system is currently in operation, with Lines 2 and 3 now under construction.

The range of public transport modes that exist in KL poses the question of why MRT was chosen over other available options, such as bus rapid transit. According to the Land Public Transport Master Plan, the KL Local Plan calls for the public transport modal share to increase from 18 percent to 40 percent by 2020. The Land Public Transport authority believes that the MRT project addresses several key challenges, such as urban sprawl due to population increase, poor existing intra-modal and inter-modal integration between various public transport modes, and unsustainable growth in private transport demand. The project is intended to substantially expand rail network coverage and capacity; provide adequate connectivity between modes and rail lines; and run rail lines through high travel demand areas. In terms of connectivity, the MRT Lines in KL will have four interchange stations that would allow passengers to transfer between lines easily. In addition, the MRT in KL is intended to create an economically efficient urban environment; improve productivity, and promote social equality and quality of life in the Klang Valley. In addition, the project’s proponents make the case that it will effect travel-time savings, reductions in vehicle operating costs, and reductions in accidents (as rail is much safer than road transport). In addition, the reduction in vehicle emissions resulting from the shift from road to rail is expected to be substantial. Other benefits such as economic growth, job creation and increased tax revenues to the government are anticipated to continue during the latter phases of construction.

The MRT project in Malaysia—part of the country’s comprehensive National Transformation Programme—is intended to propel Malaysia to developed-nation status by 2020. Three lines have been planned for the Klang Valley MRT Project. Line 1 is the main subject of this study (Figure 2): the 51 km MRT Sungai Buloh-Kajang (SBK) Line (known as MRT SBK Line). It originates in Sungai Buloh, located to the northwest of Kuala Lumpur, and runs through the city center before ending in Kajang, a rapidly developing town to the southeast of the city. The line runs underground for a distance of 9.5 km beneath the center of Kuala Lumpur, while the rest of the alignment is elevated. The SBK Line has 31 stations, of which seven are underground.

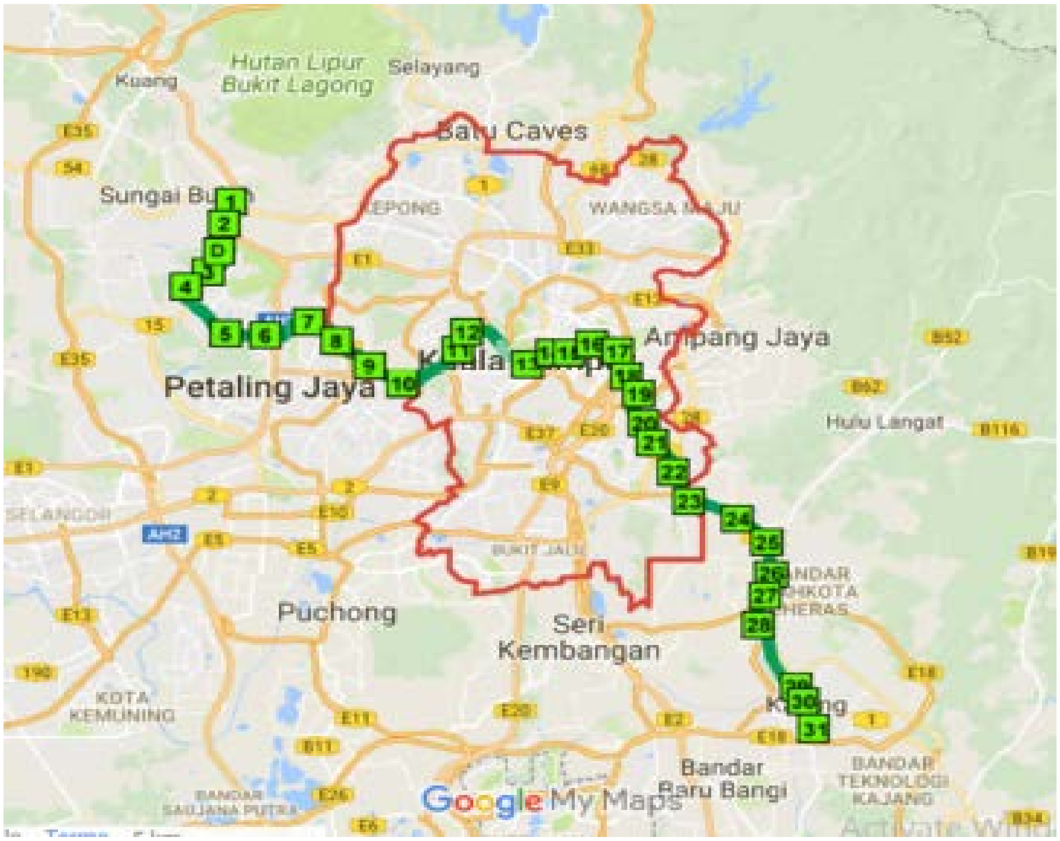

Figure 2. The 31 stations of the MRT SBK Line in Greater Kuala Lumpur

Each train serving the line has four cars, accommodating a total of 1,200 passengers. The daily ridership is estimated to be about 400,000 passengers. Trains run at a frequency of 3.5 minutes at peak hours. Figure 3 displays MRT ridership in Kuala Lumpur, as recorded since the first MRT Line began operating in December 2016. Figure 3 shows a significant increase in the number of passengers between August and September, due to half prices fares offered during the Southeast Asian (SEA) Games leading up to Hari Merdeka, or Malaysian Independence Day, on August 31.

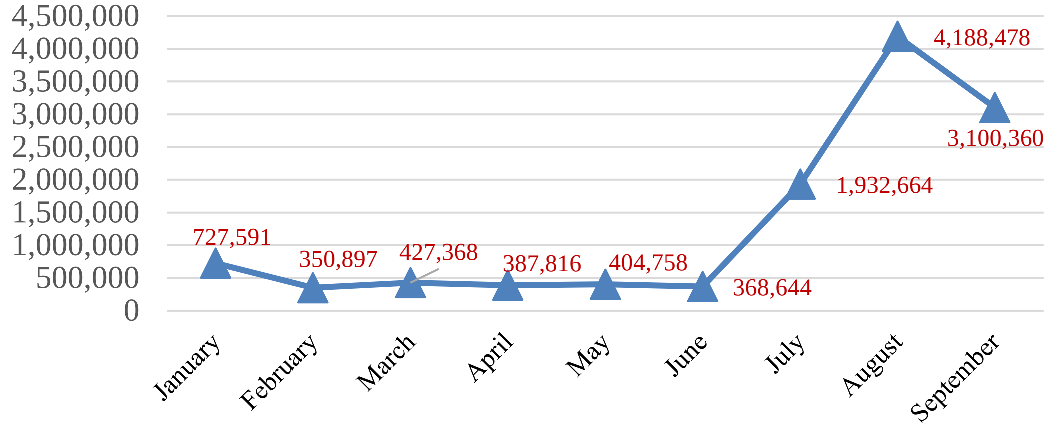

Figure 3. MRT SBK line ridership, January 2017−September 2017[2]

The second MRT line in KL is the Sungai Buloh-Serdang-Putrajaya Line (known as MRT SSP Line or MRT2), which will be 53 km long. Presently it is 10 percent complete, and is due to open in two phases in 2021 and 2022. The third line, known as the “circle line” but still without a formal name, will a 40-km to 50-km loop. It is now in the feasibility-study stage.

In terms of MRT project management, plan, and design, the Land Public Transport Commission (Suruhanjaya Pengangkutan Awam Darat, known as SPAD) plans, regulates, and enforces all matters related to land public transport in Peninsular Malaysia. It is, therefore, the supervising agency for the MRT project. A separate entity, Mass Rapid Transit Corporation Sdn Bhd (known as MRT Corp) was set up in 2011 to develop and own the assets of the MRT system. It is, in turn, fully owned by the Minister of Finance. MRT Corp is responsible for the procurement process, awarding of contracts, monitoring construction, dispute resolution, scheduling adherence, and compliance with health, safety, security, and environment requirements. Finally, Prasarana Malaysia Berhad (Prasarana) is a 100 percent government-owned company set up by the Ministry of Finance that owns the assets of all multi-modal public transport in Malaysia, as part of the government's larger efforts to restructure the city's public transport system. Prasarana acts as a co-operator of MRT.

Research Methodology

Data Collection

This study's scope and problem statement were defined through an initial review of literature, government reports, and blog articles. It is informed by both secondary data and survey (primary) data. Secondary data was collected from the websites of MRT Corporation, the Ministry of Transport Malaysia, and SPAD. Information on stations, facilities, interchange, bus, number of units, size of unit, type of business, name of shops, etc. at each station have been collected from the official SBK MRT Line website. These were then sorted into a spreadsheet matrix before being integrated with the primary data.

Primary data were obtained from fieldwork that was conducted between September 2017 and January 2018. A semi-structured questionnaire was used to collect baseline data, which were then combined with data from participatory methods (i.e., informant interviews and in-depth interviews) to generate meaningful qualitative data. The semi-structured questionnaire was written in both English and Malaysian, and consisted of three parts: location and demographic characteristics, trip characteristics, and public perception of the current challenges of MRT. The survey was conducted at all 31 MRT stations in Kuala Lumpur.

In all, 106 questionnaires were conducted on site with individuals who live near MRT stations in Kuala Lumpur. The participants, selected at random, were interviewed face-to-face by research assistants who served as local interviewers. To avoid oversampling from a particular station, no more than six people were interviewed at any MRT station. To test the reliability of the questionnaire, 12 people were selected as pilots. Once compiled, the data were then disaggregated by social characteristics, including gender, education, and occupation. In addition, to represent the views of local transportation authority officials, five in-depth interviews were conducted, with representatives from Prasarana Malaysia Berhad (Prasarana), the Mass Rapid Transit Corporation Sdn Bhd (MRT Corp.), the Land Public Transport Commission (SPAD: Suruhanjaya Pengangkutan Awam Darat), and a member of Parliament (two interviews).

Analysis

A qualitative technique was employed to interpret and analyze the collected data. Survey results were compiled for the purpose of data editing, "cleaning," and data coding. Data processing and analysis were performed using Stata. Data analysis of information gathered from the questionnaire was sorted in the form of tables.

The analysis process was conducted in three steps. First, a statistical analysis was conducted to determine the distribution of the survey sample and the respondents' characteristics. (This step reveals whether there is a difference between users' characteristics and their responses to questions about accessibility and connectivity at each MRT station in KL.) Second, after cleaning the information obtained from the collection of secondary data, that information was imported into one spreadsheet matrix, enabling researchers to assess the current state of accessibility and connectivity at each of the 31 MRT stations. This step identifies facilities that are available in each of the stations, and how they contribute to the accessibility and connectivity of each MRT station. Third, the information derived through this the second step is integrated with the respondents' answers in the survey corresponding to the MRT station in the second step. This method enabled the researchers to capture how elements relating to accessibility and connectivity at each MRT station affect the user's MRT ride.

To make this possible, the respondents at each MRT station were asked: "Given the current facilities provided at the nearest MRT station (park and ride, sign, information, interchange, frequency of train, and other facilities), how many times in a typical week do you ride MRT in Kuala Lumpur?" Based on this information, the average number of trips per user was calculated at each MRT station—data that could then be cross-referenced with the results in the accessibility and connectivity matrix for each MRT station. Again, the aim was to determine whether there is a discernible relationship between the accessibility and connectivity and the actual ridership—and by extension, to determine how users and non-users respond to the current state of accessibility and connectivity at each MRT station.

Findings and results

Distribution of sample

Table 1 represents the distribution of the 106 respondents at each MRT station of the SBK MRT Line who participated the survey. Passengers at all 31 MRT stations were surveyed. Bandar Utama, Parsa Sani and Sematan stations had the largest number of respondents (6 respondents, 5.6 percent), followed by Bukit Bintang (5 respondents, 4.72 percent). Kwasa Damansara, Mutiara Damansara, Muzium Negara, Phileo Damansara, Sri Raya, Sungai Buloh, Sugai Jernih, Taman Connaught and Taman Mutiara stations had 4 respondents for the survey. Each of the remaining MRT stations had either 2 or 3 respondents.

No.	Name of MRT station	Frequency
1	Bandar Utama (BU)	6
2	Batu Sebelas Cheras (BSC)	2

No.	Name of MRT station	Frequency
3	Bukit Bintang (BB)	5
4	Bukit Dukung (BD)	2
5	Cochrane (CO)	3
6	Hussien Onn (HO)	3
7	Kajang (KJ)	3
8	Kampung Selamat (KS)	2
9	Kota Damansara (KD)	3
10	Kwasa Damansara (KwD)	4
11	Kwasa Sentral (KwS)	3
12	Maluri (MA)	3
13	Merdeka (ME)	2
14	Mutiara Damansara (MD)	4
15	Muzium Negara (MN)	4
16	Pasar Seni (PS)	6
17	Phileo Damansara (PD)	4
18	Pusat Bandar Damansara (PBD)	2
19	Semantan (SE)	6
20	Sri Raya (SR)	4
21	Stadium Kajang (SK)	3
22	Sungai Buloh (SB)	4
23	Sungai Jernih (SJ)	4
24	Surian (SU)	3
25	Taman Connaught (TC)	4
26	Taman Midah (TMi)	3
27	Taman Mutiara (TMu)	4
28	Taman Pertama (TP)	3
29	Taman Suntex (TS)	2
30	Taman Tun Dr Ismail (TTDI)	3
31	Tun Razak Exchange (TRX)	2
	Total	106

Table 1. Distribution of respondents at 31 MRT stations in Kuala Lumpur

Users' characteristics

Table 2 illustrates the demographic characteristics of the survey respondents at the 31 stations. Among 106 respondents, more than half (54 percent) were male, and 63 percent of the respondents had a university degree. The majority of respondents (57.4 percent) worked in companies (48.0 percent), government positions (4.7 percent), or self-owned business (4.7 percent). More than 40 percent of respondents were not working, including students and unemployed or temporary workers. The average income of respondents ranged from 3,000−5,000 MYR per month (USD $755−1,260). Pearson's Chi-square test at 95 percent confidence level reveals that there is no difference between the user's characteristics at the various stations along the SBK MRT Line. These results imply that the characteristics of respondents do not matter when considering the effect of accessibility and connectivity on the MRT user's ride. Table 1 also shows that 56 percent of 106 respondents in the sample own private vehicles. The majority of respondents (80 percent) make trips very often (>10 trips per week: 26 percent), often (6-9 trips per week: 30 percent), moderate (4-5 trips per week: 24 percent). The results mean that the traveling need of respondents living around MRT station are high.

	MRT station																														Total	(%)	Pearson chi-square	Sig.
Respondents' characteristics	BU	BSC	BB	BD	CO	HO	KJ	KS	KD	KwD	KwS	MA	ME	MD	MN	PS	PD	PBD	SE	SR	SK	SB	SJ	SU	TC	TMi	TMu	TP	TS	TTDI	TRX				
1. Gender																																			
Female	3	2	1	2	1	1	2	1	1	3	2	0	1	1	2	2	2	1	4	3	1	2	2	2	1	1	3	0	0	1	1	49	0.46	22.65	0.829
Male	3	0	4	0	2	2	1	1	2	1	1	3	1	3	2	4	2	1	2	1	2	2	2	1	3	2	1	3	2	2	1	57	0.54		
Total	6	2	5	2	3	3	3	2	3	4	3	3	2	4	4	6	4	2	6	4	3	4	4	3	4	3	4	3	2	3	2	106	100		
2. Education																																			
Non university	1	1	1	0	1	0	2	0	0	2	1	0	0	1	4	3	1	0	3	1	1	3	3	1	0	1	2	1	2	2	1	39	0.37	34.11	0.276
University	5	1	4	2	2	3	1	2	3	2	2	3	2	3	0	3	3	2	3	3	2	1	1	2	4	2	2	2	0	1	1	67	0.63		
Total	6	2	5	2	3	3	3	2	3	4	3	3	2	4	4	6	4	2	6	4	3	4	4	3	4	3	4	3	2	3	2	106	100		
3. Income																																			
<MYR 1,200/month	2	1	0	2	1	1	3	1	2	2	2	0	0	1	3	3	2	0	2	2	2	3	4	1	0	0	1	0	2	2	0	45	0.42	142.56	0.078
MYR 1,200-3,000/month	0	1	2	0	1	0	0	0	0	1	0	1	0	1	1	2	1	1	4	2	1	0	0	2	0	1	2	3	0	1	1	29	0.27		
MYR 3,001-5,000/month	2	0	2	0	1	2	0	0	1	1	0	2	1	0	0	1	1	1	0	0	0	1	0	0	4	1	1	0	0	0	1	23	0.22		
MYR 5,001-10,000/month	2	0	0	0	0	0	0	0	0	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	5	0.05		
> MYR 10,000/month	0	0	1	0	0	0	0	1	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4	0.04		
Total	6	2	5	2	3	3	3	2	3	4	3	3	2	4	4	6	4	2	6	4	3	4	4	3	4	3	4	3	2	3	2	106	100		
4. Occupation																																			
Company staff	4	1	5	0	2	1	0	1	0	1	0	3	1	3	0	1	2	2	2	2	2	1	0	0	3	3	3	3	0	3	2	51	0.48	138.74	0.116
Government officer	0	0	0	0	0	0	1	0	0	0	1	0	0	0	1	0	0	0	0	1	0	0	0	1	0	0	0	0	0	0	0	5	0.047		
Self-business	0	1	0	0	0	1	0	0	0	1	0	0	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	5	0.047		
Student	2	0	0	2	1	1	2	1	3	2	2	0	0	1	3	5	2	0	3	1	1	3	3	2	1	0	0	0	2	0	0	43	0.408		
Other	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	0	0	0	0	2	0.018		
Total	6	2	5	2	3	3	3	2	3	4	3	3	2	4	4	6	4	2	6	4	3	4	4	3	4	3	4	3	2	3	2	106	100		
5. Vehicle in household (car, motorbike)																																			
No vehicle	2	1	1	1	1	0	1	1	2	1	2	1	0	0	2	2	3	1	4	1	3	1	3	2	1	1	2	2	2	2	1	47	0.44	25.77	0.687
Vehicles	4	1	4	1	2	3	2	1	1	3	1	2	2	4	2	4	1	1	2	3	0	3	1	1	3	2	2	1	0	1	1	59	0.56		
Total	6	2	5	2	3	3	3	2	3	4	3	3	2	4	4	6	4	2	6	4	3	4	4	3	4	3	4	3	2	3	2	106	100		
6. Trip per week																																			
Very often (>10 trips)	4	1	1	1	0	1	1	0	2	1	1	0	0	0	0	0	1	1	5	0	0	0	1	2	0	0	1	0	0	3	1	28	0.26	135.69	0.135
Often (6-9 trips)	1	0	3	0	1	1	1	0	0	1	2	3	1	1	2	0	2	1	1	1	1	1	0	0	1	2	0	2	2	0	1	31	0.30		
Moderate (4-5 trips)	0	1	0	1	2	1	1	1	1	1	0	0	0	1	1	2	1	0	0	0	1	0	2	1	3	1	2	1	0	0	0	25	0.24		
Less often (2-3 trips)	1	0	0	0	0	0	0	1	0	1	0	0	0	0	0	2	0	0	0	1	0	2	0	0	0	0	0	0	0	0	0	8	0.07		
Very less often (<2 trips)	0	0	1	0	0	0	0	0	0	0	0	0	1	2	1	2	0	0	0	2	1	1	1	0	0	0	1	0	0	0	0	14	0.13		
Total	6	2	5	2	3	3	3	2	3	4	3	3	2	4	4	6	4	2	6	4	3	4	4	3	4	3	4	3	2	3	2	106	100		

Table 2. Characteristics of respondents

Additionally, the respondents were asked to indicate their place of residence, their nearest MRT station, and the total number of members in their household. The average distance between respondents' residential location/origin and their nearest MRT station was 5.9 km. Measurement of distance from place of residence to an MRT station was classified into three categories:

- *Location type I*—within one kilometer radius from the nearest MRT station (12.3 percent),
- *Location type II*—between two and 9 kilometers radius from the MRT station (71.7 percent),
- *Location type III*—more than 9 kilometers from the nearest MRT station (16.0 percent).

The descriptive analysis of the users' characteristics yielded two conclusions. First, most respondents live far from their nearest MRT station. This implies that to encourage MRT users, maximizing the accessibility and connectivity at the nearest MRT stations should be considered to encourage the respondents living around stations. Second, there is no difference between the characteristics of respondent groups that do not make a bias of the analysis results when studying the effect of accessibility and connectivity on MRT user's ride. Before understanding how accessibility and connectivity at each MRT station affect MRT users' ride, therefore, we examine the current state of accessibility and connectivity at MRT stations.

Current accessibility of the SBK MRT Line

Table 3 presents the results of statistical analysis of elements of accessibility at the 31 MRT stations in Kuala Lumpur. Elements of accessibility are divided into three groups: facilities for pedestrian and bicycle access, facilities for disabled users, and incentives.

With respect to facilities for pedestrian and bicycle access, the results in Table 3 indicate that escalators, lifts, stacked platforms, public toilets, public telephones, pray room, ticket machines, and a customer service office are fully provided for non-disabled people at the stations. However, although there are some small retailers in the MRT stations (23 out of 31 stations), there are no shopping centers or large stores in these stations to encourage ridership. Furthermore, park-and-ride facilities and bicycle parking were available only at 10 and 5 stations, respectively. Rates for these services range from 1.10 to 16.10 MYR per day, depending on how long vehicles or bicycles are parked and whether drivers are MRT users or not.

The statistical results of the survey also show that the majority of respondents (52.69 percent) use a car to reach an MRT station from their home (Figure 3). Taken together, the results imply that given the tendency to use private vehicles to reach MRT stations, existing park-and-ride facilities and bicycle parking are inadequate. The park-and-ride charge for MRT users, moreover, is MYR 4.3—a relatively high parking fee, most likely discouraging ridership. The statistical results in Table 3 show that all MRT stations fully provide facilities and services for disabled users (for example, ramp access, low lift button for wheelchair users, disabled-friendly toilets, low counters for wheel chair users, and staff at stations for assistance). These resources presumably encourage disabled people to use MRT instead of private vehicles.

Another issue affecting accessibility is the lack of integration of fare cards across various transport modes. Table 3 reveals that although the MyRapid card is integrated with the LRT, BRT, RapidKL bus, and monorail networks, it is not integrated with other public transport modes owned and operated by various other companies (such as KLAI, KTM, MRT, etc.). By contrast, the Touch'n Go card—a prepaid smartcard that uses Mifare contactless technology—is also integrated with KTM lines, LRT lines, BRT lines, monorails, and major bus companies, and can be used to pay tolls on highways, and even as a debit card in some stores, shopping malls,l and car parks—none of which are available through MyRapid. But users can only buy Touch'n Go cards at a limited number of hubs; whereas MyRapid cards are available at all LRT stations and bus hubs, making them more convenient for users. These discrepancies confuse riders, and presumably affect their MRT use.

With regard to fare discounts on MRT, the fare ranges from 1.1 MYR to a maximum fare of 6.4 MYR per ride, based on the cash fare structure. Users can enjoy savings by using the Touch'n Go card's cashless-payment mode. The fare in that case ranges between 1.1 and 5.5 MYR per ride. Table 3 indicates that people with disabilities, students, and senior citizens are offered an additional 50 percent discount from the cash rate. Children under 7 years old travel for free.

"AV" means Available at this station

	Elements relating to accessibility	MRT Station Code																														
		BU	**BSC**	**BB**	**BD**	**CO**	**HO**	**KJ**	**KS**	**KD**	**KwD**	**KwS**	**MA**	**ME**	**MD**	**MN**	**PS**	**PD**	**PBD**	**SE**	**SR**	**SK**	**SB**	**SJ**	**SU**	**TC**	**TMi**	**TMu**	**TP**	**TS**	**TTDI**	**TRX**
Facilities for pedestrian and bicycle access	Escalator	AV	AV	AV	AV	AV	AV	AV	AV	AV	AV	AV	AV	AV	AV	AV	AV	AV	AV	AV	AV	AV	AV	AV	AV	AV	AV	AV	AV	AV	AV	AV
	Lift	AV	AV	AV	AV	AV	AV	AV	AV	AV	AV	AV	AV	AV	AV	AV	AV	AV	AV	AV	AV	AV	AV	AV	AV	AV	AV	AV	AV	AV	AV	AV
	Signage and information	AV	AV	AV	AV	AV	AV	AV	AV	AV	AV	AV	AV	AV	AV	AV	AV	AV	AV	AV	AV	AV	AV	AV	AV	AV	AV	AV	AV	AV	AV	AV
	Side/side stacked platform	AV	AV	AV	AV	AV	AV	AV	AV	AV	AV	AV	AV	AV	AV	AV	AV	AV	AV	AV	AV	AV	AV	AV	AV	AV	AV	AV	AV	AV	AV	AV
	Public toilets	AV	AV	AV	AV	AV	AV	AV	AV	AV	AV	AV	AV	AV	AV	AV	AV	AV	AV	AV	AV	AV	AV	AV	AV	AV	AV	AV	AV	AV	AV	AV
	Public telephone	AV	AV	AV	AV	AV	AV	AV	AV	AV	AV	AV	AV	AV	AV	AV	AV	AV	AV	AV	AV	AV	AV	AV	AV	AV	AV	AV	AV	AV	AV	AV
	Pray room	AV	AV	AV	AV	AV	AV	AV	AV	AV	AV	AV	AV	AV	AV	AV	AV	AV	AV	AV	AV	AV	AV	AV	AV	AV	AV	AV	AV	AV	AV	AV
	Park and ride	AV	n/a	n/a	AV	n/a	AV	AV	n/a	n/a	n/a	AV	AV	n/a	n/a	n/a	n/a	AV	AV	n/a	n/a	n/a	AV	AV	n/a	n/a	AV	n/a	n/a	AV	n/a	n/a
	Bicycle parking	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	AV	AV	n/a	n/a	n/a	n/a	AV	AV	AV	n/a	n/a	n/a	AV	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
	Retail store	1	2	3	2	n/a	2	n/a	2	2	n/a	2	n/a	n/a	1	1	n/a	n/a	2	2	2	1	2	1	1	1	2	1	2	1	1	n/a
	Ticket machine	AV	AV	AV	AV	AV	AV	AV	AV	AV	AV	AV	AV	AV	AV	AV	AV	AV	AV	AV	AV	AV	AV	AV	AV	AV	AV	AV	AV	AV	AV	AV
	Customer service office	AV	AV	AV	AV	AV	AV	AV	AV	AV	AV	AV	AV	AV	AV	AV	AV	AV	AV	AV	AV	AV	AV	AV	AV	AV	AV	AV	AV	AV	AV	AV
	Card integration	Touch'n Go card (Cashless) is integrated with KTM lines, LRT lines, BRT lines, monorails, major buses company, and others more ; MyRapid card is integrated only with LRT, BRT, RapidKL bus, and monorail networks, not with KLIA, KTM, MRT, etc.																														
Facilities for disabled users	Ramp access	AV	AV	AV	AV	AV	AV	AV	AV	AV	AV	AV	AV	AV	AV	AV	AV	AV	AV	AV	AV	AV	AV	AV	AV	AV	AV	AV	AV	AV	AV	AV
	Tactile tiles	AV	AV	AV	AV	AV	AV	AV	AV	AV	AV	AV	AV	AV	AV	AV	AV	AV	AV	AV	AV	AV	AV	AV	AV	AV	AV	AV	AV	AV	AV	AV
	Disabled-friendly toilets	AV	AV	AV	AV	AV	AV	AV	AV	AV	AV	AV	AV	AV	AV	AV	AV	AV	AV	AV	AV	AV	AV	AV	AV	AV	AV	AV	AV	AV	AV	AV
	Low lift button for wheel chair users	AV	AV	AV	AV	AV	AV	AV	AV	AV	AV	AV	AV	AV	AV	AV	AV	AV	AV	AV	AV	AV	AV	AV	AV	AV	AV	AV	AV	AV	AV	AV
	Braille for the lift buttons	AV	AV	AV	AV	AV	AV	AV	AV	AV	AV	AV	AV	AV	AV	AV	AV	AV	AV	AV	AV	AV	AV	AV	AV	AV	AV	AV	AV	AV	AV	AV
	Staff at station to provide assistance	AV	AV	AV	AV	AV	AV	AV	AV	AV	AV	AV	AV	AV	AV	AV	AV	AV	AV	AV	AV	AV	AV	AV	AV	AV	AV	AV	AV	AV	AV	AV
	Low counters for wheel chair users	AV	AV	AV	AV	AV	AV	AV	AV	AV	AV	AV	AV	AV	AV	AV	AV	AV	AV	AV	AV	AV	AV	AV	AV	AV	AV	AV	AV	AV	AV	AV
Incentives	Fare discount	50 percent discount for people with disabilities (OKU), students, and senior citizens (MyKad), children under 7 years old travel for free																														
	Feeder bus discount	50 percent discount for people with disabilities (OKU), students, and senior citizens (MyKad), children under 7 years old travel for free																														

Table 3. Characteristics of current accessibility at 31 MRT stations in Kuala Lumpur

Current connectivity of the SBK MRT Line

Table 4 displays the characteristics of connectivity at 31 MRT stations in Kuala Lumpur. Connectivity comprises three elements: availability of feeder buses that bring passengers to and from the station, interchanges with other transport modes, and frequency of train departures. The majority of stations (26 out of 31) provide feeder buses. A total of 300 feeder buses have been deployed to cover 49 routes at 26 MRT stations. The frequency of feeder bus stops ranges from 10 to 15 minutes. A nominal fare of 1.0 MYR per trip is set for the MRT feeder bus services, and can be paid with cash or Touch 'n Go cards. As with the MRT fares, senior citizens, students, and disabled people are offered a 50 percent discount, and children under 7 years old travel for free.

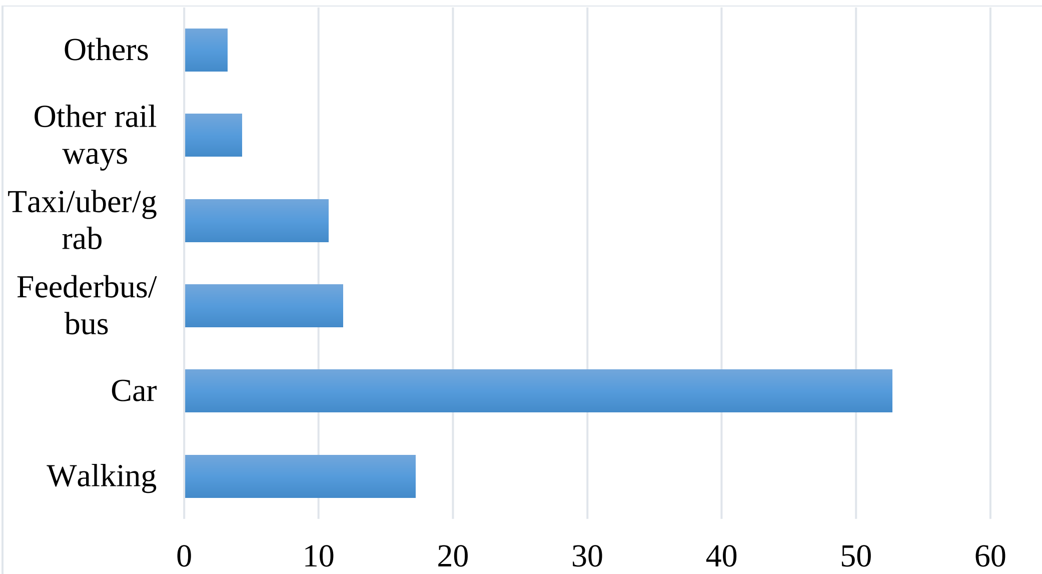

Figure 4. Mode choice shares for travel from home to nearest MRT station[3]

The statistical analysis in Figure 4, however, shows that only 11.83 percent of respondents use feeder bus service to reach the MRT station. This rate is relatively low, given government efforts to encourage people to use public transport. This suggests that more feeder buses in many different residential areas ought to be provided to accommodate more MRT riders.

Connectivity	Number of MRT stations

	connected with
Feeder buses	27
KL Monorail Line	02
KTM Seremban Line	02
KTM Port Klang Line	02
LRT Ampang Line	02
LRT Sri Petaling Line	01
LRT Kelana Jaya Line	02
KLIA Ekspres Line	01
KLIA Transit Line	01
KL Rapid Bus	01

Table 4. Current connectivity at 31 MRT stations in Kuala Lumpur[4]

Another important element of connectivity is the opportunity for interchange at each MRT station. Table 4 shows that only 7 out of 31 stations have been connected with other public transport modes in the city. Only one of these seven (Muzium Negara station) is connected to most of the other rail networks in Kuala Lumpur, while two (Merdeka and Pasar Seni stations) have two rail connections each. The other four stations only connect with one other public transport mode. In other words, connectivity is poor for the SBK MRT Line in Kuala Lumpur—a central obstacle to encouraging people to use MRT.

Furthermore, as shown in Table 4, the average frequency of MRT trains is 6.2 minutes from Monday to Thursday, 5.9 minutes on Fridays, 7.7 minutes on Saturdays, and 7.6 minutes on Sundays and public holidays. This implies that users' waiting time is quite short—and in fact, survey respondents confirmed that the frequency of trains meets their expectations. When asked "How satisfied are you with the current frequency of MRT train?" almost 90 percent answered that they were satisfied with the frequency of the MRT. The remaining respondents suggested that the MRT should run twenty-four hours per day, instead of suspending operations at midnight.

The effects of accessibility and connectivity on users' MRT experience

As Tables 3 and 4 illustrate, the majority of facilities that affect accessibility (such as escalator, lift, signage and information, public toilets, public telephone, ramp access, etc.) are available at all 31 MRT stations. Yet several elements that would further improve accessibility are still lacking at several stations. Figure 5 summarizes the accessibility and connectivity elements at MRT station. Accessibility features like park-and-ride and bicycle parking are not provided at 19 and 26 MRT stations, respectively. As referenced in Figure 4, more than half of users (52.69 percent) prefer to reach their local MRT stations by car, so the lack of park-and-ride at most MRT station makes it inconvenient for users to access MRT.

Figure 5 also reveals that although smaller retail stores are located at 23 out of 31 MRT stations, there are no major shopping centers co-located at MRT stations. The latter can attract greater ridership because users can save time and money by combining their MRT ride and shopping in the same trip. When survey respondents were asked “If one thing could be changed, what would you suggest so that you will ride MRT more?,” 37 percent suggested that shopping centers or retails stores should be co-located at all MRT stations. Responses indicate that food and beverage retailers would fill a need (“Sometimes we are very thirsty and need to purchase a beverage, they but there are no retail stores or shops in MRT stations”), and that riders recognize the potential time savings of shopping by MRT stations (“We go shopping on the way back home after working; [doing so by the MRT] saves our time”).

Figure 5. Availability of accessibility and connectivity elements at SBK MRT stations

Figure 5 indicates that connectivity of the SBK MRT Line in Kuala Lumpur faces some challenges in terms of feeder bus services, interchange options and linked fare pass. Although feeder buses are provided at 27 out of 31 stations, 71 percent of respondents agreed that more feeder buses should be provided in additional densely-populated areas, should run more frequently, and should arrive/depart on schedule. Another major challenge of connectivity at MRT stations is the option for interchange with other transport lines. As only 7 MRT stations are connected with other public transport modes, interchange at MRT stations is poor, and likely prevents greater MRT use. This limitation should be a significant concern for the Kuala Lumpur transportation authorities.

A third crucial element that determines the degree of MRT's connectivity is availability of a linked pass. Figure 5 reveals that there are no linked passes provided at MRT stations so far. As noted above, pass cards (such as Touch'n Go and Mypaid cards) available at MRT stations are only integrated with services owned by the same company, which includes LRT, feeder buses and monorail but not the not KTM train or KLIA networks that offer service to Kuala Lumpur's international airports. This is a missed opportunity to provide a convenient service for travelers and tourists. In addition, 70 percent of interviewees expressed that "MRT, LRT and other transport modes need to be connected into one system because we do not need more transportation and do not want to pay more.". This implies that public transport users' need for a linked pass is very high, and should be carefully considered to improve MRT connectivity

In order to understand the effects of the current accessibility and connectivity at MRT stations on residents' decision to use the MRT, respondents were asked: "Given the current facilities (accessibility and connectivity) provided at the nearest MRT station, how many times in a typical week do you ride MRT in Kuala Lumpur?" Table 5 displays these responses, showing that the average number of rides in a typical week was appropriately 3 times. This seems that the average number of trips per user at each MRT station is relative low in a typical week. But if MRT were convenient to take to and from work, it seems likely that users would take it 10 times per week (2 times per day X 5 days per week).

MRT stations	Connectivity			Accessibility			Average number of trips per user per week
	Feeder bus	Interchange with	Linking pass	Park and ride	Bicycle parking	No. of retail stores	
Muzium Negara (MN)	X	KTM Seremban line KTM Port Klang line LRT Kelana Jaya Line KLIA Ekspres Line KLIA Transit Line KL Monorail Line	X	X	X	1	6.3
Pasar Seni (PS)	X	LRT Kelana Jaya Line KL Rapid Bus	X	X	√	X	5.2
Semantan (SE)	√	X	X	X	X	2	4.5
Maluri (MA)	√	LRT Ampang Line	X	√	X	X	4.3
Bukit Bintang (BB)	X	KL Monorail Line	X	X	X	3	4.2
Bandar Utama (BU)	√	X	X	√	X	1	4.0

Merdeka (ME)	X	LRT Ampang Line LRT Sri Petaling Line	X	X	X	X	4.0
Taman Pertama (TP)	√	X	X	X	X	2	3.7
Sungai Buloh (SB)	√	X	X	√	√	2	3.5
Taman Suntex (TS)	√	X	X	√	X	1	3.5
Hussien Onn (HO)	√	X	X	√	X	2	3.3
Stadium Kajang (SK)	√	X	X	X	X	1	3.3
Taman Connaught (TC)	√	X	X	X	X	1	3.3
Batu Sebelas Cheras (BSC)	√	X	X	X	X	2	3.0
Cochrane (CO)	√	X	X	X	X	X	3.0
Phileo Damansara (PD)	√	X	X	√	√	X	2.8
Taman Mutiara (TMu)	√	X	X	X	X	1	2.8
Kajang (KJ)	√	KTM Seremban line	X	√	X	X	2.7
Kwasa Sentral (KwS)	√	X	X	√	√	2	2.7
Surian (SU)	√	X	X	X	X	1	2.7
Taman Midah (TMi)	√	X	X	√	X	2	2.7
Bukit Dukung (BD)	√	X	X	√	X	2	2.5
Kwasa Damansara (KwD)	√	X	X	√	√	X	2.5
Pusat Bandar Damansara (PBD)	√	X	X	√	√	2	2.5
Tun Razak Exchange (TRX)	X	X	X	X	X	X	2.5
Kota Damansara (KD)	√	X	X	√	X	2	2.3
Taman Tun Dr Ismail (TTDI)	√	X	X	X	X	1	2.3
Sri Raya (SR)	√	X	X	X	X	2	1.8
Sungai Jernih (SJ)	√	X	X	√	X	1	1.8
Mutiara Damansara (MD)	√	X	X	X	X	1	1.5
Kampung Selamat (KS)	√	X	X	X	X	2	0.5
Average number of trips per user per week at the nearest MRT station (SBK MRT Line)							3.1

Table 5. The effects of accessibility and connectivity on the average number of trips per user per week[5]

The survey also explored the effects of connectivity and accessibility on how often each station is frequented by users. Figure 6 shows the average number of trips made by survey respondents from each MRT station. Among 31 MRT stations, Kampung Selemat has the lowest average rides (0.5), while the highest average number of rides is Muzium Negara with appropriately 6.0 trips.

As seen in Figure 6, the effects of accessibility and connectivity on users' choice to ride the MRT can be categorized into three groups. The first group is that the average number of trips per user ranges from 4 to more than 6 times per week including Muzium Negara, Semantan, Bukit Bintang, and Merdeke stations. These stations have a relatively high average number of trips per user because they are connected with other public transport modes, despite lacking some elements relating to accessibility (Table 5). Although Semantan Station does not yet have connections to any other public transport modes, the average number of trips per user through that station is quite high because the headquarters of MRT Corporation is located there, and MRT Corporation staff ride for free with their staff card. Moreover, several office and residential buildings are located very close to this station.

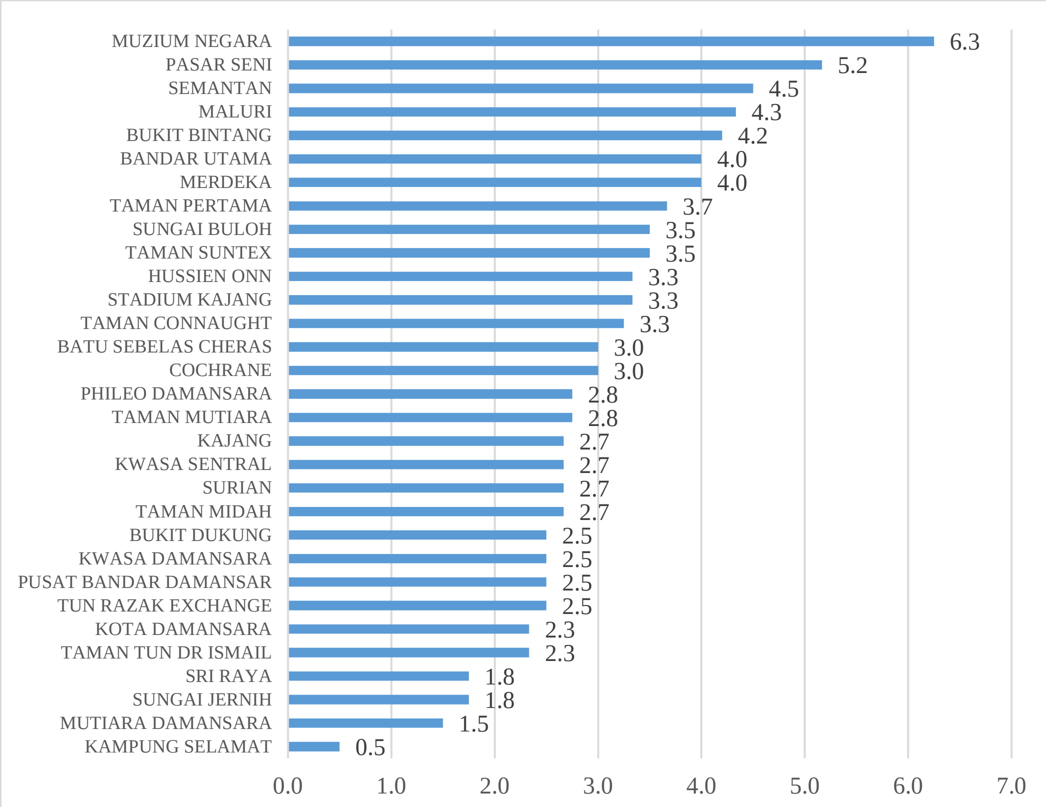

Figure 6. Average number of MRT station uses in a typical week

The second group of stations has an average number of trips per user from more than two to less than four times per week (Figure 6). A possible explanation for the results of the second group is that all the stations of the second group provide feeder buses, which encourage users. The average number of trips per user at these stations, however, could be higher if linked passes and facilities like retail and park-and-ride were available.

The average number of trips per user of the third group of stations (Sri Raya, Sungai Jernih, Mutiara Damansara, and Kampung Selamat) varies from less than one to below two trips per week. The low average number of trips per week can be attributed to—apart from the lack of interchange and lack of some accessibility elements—the distance from these MRT stations to more remote residential areas that are not served by feeder buses.

To further explore the effects of accessibility and connectivity on MRT use, five in-depth interviews were conducted with the representatives of Prasarana Malaysia Berhad, the Mass Rapid Transit Corporation Sdn Bhd (MRT Corp.), the Land Public Transport Commission (SPAD), and a member of Parliament (two interviews). In each interview, the authorities were asked, “What are some ways to increase MRT ridership going forward?” Representatives of Prasarana and MRT Corp. proposed that although the number of ridership has grown rapidly, first- and last-mile connectivity should be improved by providing more feeder buses in areas that are not as dense as the urban core. Additionally, they suggested that operators need to collaborate to establish attractive shopping centers in or near MRT stations to encourage users. Furthermore, the representative of SPAD suggested that the city should develop a more efficient MRT system by integrating other existing public transport modes through the adoption of one linked pass, which would be more convenient to use. Another opinion from the member of Parliament was that to attract MRT ridership in the long run, the improvement of parking facilities should be considered.

Additional analyses prompted by these in-depth interviews confirmed that the survey results were robust.

Discussion

Implication of results

As the first MRT line in Malaysia, the SBK MRT Line in Kuala Lumpur still faces some challenges relating to accessibility and connectivity. These challenges include:

1) Lack of widespread feeder bus services in residential areas
2) Lack of connection with other public transport modes at many stations
3) Lack of one integrated link pass
4) Limited park-and-ride and bicycle parking at some stations, and at a high cost when available; and
5) Lack of shopping centers in MRT stations

To maximize the accessibility and connectivity of MRT to attract more riders, policy actions that address the various elements of accessibility and connectivity to target potential riders in both more and less dense areas of the city should be considered.

As noted, the lack of park-and-ride and bicycle parking at many MRT stations—as well as high parking fees—discourage users from accessing MRT, and should be remedied. These conclusions are in line with arguments made in previous studies (Prasertsubpakij and Nitivattananon 2012; Zhu and Liu 2004) that contend that maximizing accessibility is an important agenda in urban transportation planning, because it creates new services and activities which attract more people to use metros. To improve these elements, broader policies relating to land use planning and design issues need to be considered in conjunction.

The results above also reveal that although there are retail stores located in some MRT stations, the fact that there are no shopping centers in or near MRT stations is one of the key reasons why MRT is not used by more people. Establishing attractive shopping centers in or near MRT stations would create additional benefits for users, and might be one of the most effective ways to encourage people to use MRT instead of private vehicles (Soltani et al. 2012). By extension, this would also help reduce congestion and pollution in the city.

The above findings regarding accessibility indicate that the first MRT Line in KL is facing challenges of accessibility. In particular, these challenges relate to the lack of attractiveness of individual stations, including lack of park and ride, bicycle parking, and shopping centers. These findings are consistent with the main argument of the potential model (gravity model) (Geertman and Ritsema Van Eck 1995; Handy and Niemeier 1997).

With respect to connectivity, the results show that feeder-bus services currently are unreliable, run infrequently, and don't provide return trips at times that match well with users' schedules. Also, a lack of interchange between lines and modes increases users' distance travelled, relative to the actual distance between origin and destination, which in turn affects the speed of public transport like MRT (Guo and Wilson 2011).

Taken together, these results demonstrate that connectivity at MRT stations is still poor and thus users' trips are lengthy and costly. This corroborates previous studies that underscore that poor connectivity—due to unreliability of feeder bus and lack of interchange—causes many passengers to stop using MRT service (A. Ceder, Net, and Coriat 2009; A. (Avi) Ceder and Teh 2010; Papaioannou and Martinez 2015).

The results further indicate that lack of linked pass makes using MRT less convenient, as the data revealed that the average number of trips per user at MRT stations where there is no linked pass is low. Again, introducing a linked pass is a key step toward improving connectivity; (Papaioannou and Martinez 2015). One approach is to introduce a linked pass with time limits on changes between all modes of public transport, whereby a commuter who takes the feeder bus to the MRT station and then takes the MRT within one hour gets a discount on the MRT—whereas if the commuter takes the MRT an hour or more after first taking the feeder bus, the full fare for both trips will be charged. This approach would be likely to increase ridership, and still maintain revenues.

Policy recommendations for other parts of the world

This study has focused on the challenges of accessibility and connectivity of the SBK MRT Line in Kuala Lumpur, and the effects of these challenges on users' MRT-related decision-making. Now we draw on the lessons learned through this study to offer policy recommendations to improve MRT systems in other developing cities.

First, to establish an efficient MRT system, government and transportation authorities in developing countries should focus on developing an MRT system that is integrated with existing public transport systems. To do so successfully, city officials should plan ahead for an integrated transportation system, rather than attempting to integrate them after they build. This approach allows transport authorities to design and provide a link pass that can be used for any public transportation modes in the city. Additionally, it also allows authorities to extend MRT stations to areas where population density is increasing. These will be helpful not only for MRT, but also for other public transport systems, because users can take several public transport modes for their trip instead of accessing stations by means of private vehicles.

Achieving this degree of integration will require collaboration among a broad spectrum of stakeholders: system owners, operators, government local authorities, intended users, and many others. Moreover, well-designed land use and transport plans are also necessary. These plans require both a well-organized framework and coordinated stakeholders (Ka'bange, Mfinanga, and Hema 2014). Important stakeholders—such government (Ministry of Transport, Ministry of Finance, etc.), local authorities, and affected people—have to be involved in the early stages of the process.

Second, to encourage people to access to MRT stations, transport authorities should enhance first- and last-mile services by providing feeder buses that provide broad coverage to residential areas. Obviously, feeder bus schedules need to be provided at stations and bus stops, to help users plan their trips. Just as obviously, feeder buses need to follow their announced schedules. These tactics should persuade users to choose feeder buses to access MRT stations, instead of using their private vehicles.

Third, bicycle parking space need to be provided at stations, and the bicycle parking fee should be low enough to attract people who live close enough to the station to commute there by bicycle. To support these policies, at the state level, the government should add cycling infrastructure, such as protected cycling lanes. Although cycling is not common in some developing cities (including Kuala Lumpur), it has the potential to enable access to the MRT stations from a much wider catchment area than walking, and is far more space-efficient than driving.

Finally, transport authorities should collaborate with other operating companies to establish attractive shopping centers in or close to MRT stations. Providing such services would enable MRT users to combine shopping and work in the same trip—and thereby would attract more users to MRT.

Conclusion

In many cities, MRT is one of the most favored transport modes, because it features a high level of efficiency and significant energy savings—both key economic and environmental considerations. They tend to be relatively affordable, providing a premium-quality service at a reasonable fare. In addition, MRT enables integration with the existing rail networks, which strengthens reliable public transport services in cities. To implement MRT successfully, local authorities must address both accessibility and connectivity. The successful implementation of MRT can help reduce congestion and pollution, and decarbonize urban areas.

This study shows the crucial challenges of accessibility and connectivity of MRT system in Kuala Lumpur, and the effects of these challenges on users' choice to ride MRT. Station by station, these challenges comprise:

1) A lack of widespread feeder bus services in residential areas;
2) A lack of connection with other public transport modes at many stations;
3) Inadequate linkages of passes across modes;
4) Limitations on park-and-ride space/ bicycle parking at some stations, as well as relatively high parking fees and
5) A lack of shopping centers in MRT stations.

At stations that lacked such facilities, the average number of trips made through these stations was lower, arguing that these factors significantly affect users' choices to use or not use MRT. Therefore, careful planning for the development of MRT system to improve accessibility and connectivity is needed.

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References

Associates, Wilbur Smith, Moore Iacofano Goltsman, Michael Cunningham, Corinne Goodrich, and Christine Maley-grubl. 2006. “Final Summary Report MTC TRANSIT CONNECTIVITY PLAN.”

Beimborn, Edward, Michael Greenwald, and Xia Jin. 2003. “Accessibility, Connectivity, and Captivity: Impacts on Transit Choice.” *Transportation Research Record* 1835 (1): 1–9. https://doi.org/10.3141/1835-01.

Ceder, Avishai (Avi), and Chen Shi (Carolyn) Teh. 2010. “Comparing Public Transport Connectivity Measures of Major New Zealand Cities.” *Transportation Research Record: Journal of the Transportation Research Board* 2143 (1): 24–33. https://doi.org/10.3141/2143-04.

Ceder, Avishai, Yann Net, and Caroline Coriat. 2009. “Measuring Public Transport Connectivity Performance Applied in Auckland, New Zealand.” *Transportation Research Record: Journal of the Transportation Research Board* 2111: 139–47. https://doi.org/10.3141/2111-16.

Ceder, Avishai, and Supun Perera. 2014. “Detecting and Improving Public-Transit Connectivity with Case Studies of Two World Sport Events.” *Transport Policy* 33: 96–109. https://doi.org/10.1016/j.tranpol.2014.03.001.

Cervero, Robert, and Kara Kockelman. 1997. “Travel Demand and the 3Ds: Density, Diversity, and Design.” *Transportation Research Part D: Transport and Environment* 2 (3): 199–219. https://doi.org/10.1016/S1361-9209(97)00009-6.

Davidson, K B. 1977. “Accessibility in Transport/land-Use Modelling and Assessment.” *Environment and Planning A* 9 (12): 1401–16. https://doi.org/10.1068/a091401.

Djurhuus, Sune, Henning Sten Hansen, Mette Aadahl, and Charlotte Glümer. 2014. “Individual Public Transportation Accessibility Is Positively Associated with Self-Reported Active Commuting.” *Frontiers in Public Health* 2 (November): 1–9. https://doi.org/10.3389/fpubh.2014.00240.

Fouracre, Phil, Christian Dunkerley, and Geoff Gardner. 2003. “Mass Rapid Transit Systems for Cities in the Developing World.” *Transport Reviews* 23 (3): 299–310. https://doi.org/10.1080/0144164032000083095.

Fox, Halcrow. 2000. “World Bank Urban Transport Strategy Review—Mass Rapid Transit in Developing Countries Final Report July 2000.” *Department for International Development*, no. April: 246. www.halcrow.com.

Geertman, Stan C.M., and Jan R. Ritsema Van Eck. 1995. “Research Article: GIS and Models of Accessibility Potential: An Application in Planning.” *International Journal of Geographical Information Systems* 9 (1): 67–80. https://doi.org/10.1080/02693799508902025.

Givoni, Moshe, and Piet Rietveld. 2007. “The Access Journey to the Railway Station and Its Role in Passengers’ Satisfaction with Rail Travel.” *Transport Policy* 14 (5): 357–65. https://doi.org/10.1016/j.tranpol.2007.04.004.

Guo, Zhan, and Nigel H M Wilson. 2011. “Assessing the Cost of Transfer Inconvenience in Public Transport Systems: A Case Study of the London Underground.” *Transportation Research Part A: Policy and Practice* 45 (2): 91–104. https://doi.org/10.1016/j.tra.2010.11.002.

Hadas, Yuval, and Prakash Ranjitkar. 2012. “Modeling Public-Transit Connectivity with Spatial Quality-of-Transfer Measurements.” *Journal of Transport Geography* 22. Elsevier Ltd: 137–47. https://doi.org/10.1016/j.jtrangeo.2011.12.003.

Handy, S. L., and D. A. Niemeier. 1997. “Measuring Accessibility: An Exploration of Issues and Alternatives.” *Environment and Planning A* 29 (7): 1175–94. https://doi.org/10.1068/a291175.

Hodges, Tina. 2010. “Public Transportation’s Role in Responding to Climate Change.” *U.S. Department of Transportation*. https://www.transit.dot.gov/sites/fta.dot.gov/files/docs/PublicTransportationsRoleInRespondingToClimateChange2010.pdf.

How, J. 1990. “Singapore Mass Rapid Transit Project.” *Singapore Medical Journal* 31 (6): 515–18.

Ka’bange, Abdi, David Mfinanga, and Edwin Hema. 2014. “Paradoxes of Establishing Mass Rapid Transit Systems in African

Cities—A Case of Dar Es Salaam Rapid Transit (DART) System, Tanzania." *Research in Transportation Economics* 48: 176–83. https://doi.org/10.1016/j.retrec.2014.09.040.

Kaho, Todd., Johan Springael, PL Kunsch, J.P. Brans, Fabrizio Baldoni, Diego Falsini, Emanuele Taibi, et al. 2008. "Public Transportation and Petroleum Savings in the US: Reducing Dependence on Oil." *Transportation* 6 (4): 339–48. https://doi.org/10.1006/jema.2001.0488.

Kwan, Mei Po, and Joe Weber. 2003. "Individual Accessibility Revisited: Implications for Geographical Analysis in the Twenty-First Century." *Geographical Analysis* 35 (4): 341–53. https://doi.org/10.1111/j.1538-4632.2003.tb01119.x.

Kwan, Soo Chen, Marko Tainio, James Woodcock, Rosnah Sutan, and Jamal Hisham Hashim. 2017. "The Carbon Savings and Health Co-Benefits from the Introduction of Mass Rapid Transit System in Greater Kuala Lumpur, Malaysia." *Journal of Transport and Health* 6: 187–200. https://doi.org/10.1016/j.jth.2017.06.006.

Li, C. N. 2013. "Improvement and Efficiency: Mass Rapid Transit Station in Taipei." In *WIT Transactions on the Built Environment*, 130:291–302. https://doi.org/10.2495/UT130231.

Mishra, Sabyasachee, Timothy F. Welch, and Manoj K. Jha. 2012. "Performance Indicators for Public Transit Connectivity in Multi-Modal Transportation Networks." *Transportation Research Part A: Policy and Practice* 46 (7). Elsevier Ltd: 1066–85. https://doi.org/10.1016/j.tra.2012.04.006.

Moniruzzaman, Md, and Antonio Páez. 2012. "Accessibility to Transit, by Transit, and Mode Share: Application of a Logistic Model with Spatial Filters." *Journal of Transport Geography* 24: 198–205. https://doi.org/10.1016/j.jtrangeo.2012.02.006.

Morris, J. M., P. L. Dumble, and M. R. Wigan. 1979. "Accessibility Indicators for Transport Planning." *Transportation Research Part A: General* 13 (2): 91–109. https://doi.org/10.1016/0191-2607(79)90012-8.

Páez, Antonio, Darren M. Scott, and Catherine Morency. 2012. "Measuring Accessibility: Positive and Normative Implementations of Various Accessibility Indicators." *Journal of Transport Geography* 25: 141–53. https://doi.org/10.1016/j.jtrangeo.2012.03.016.

Papaioannou, Dimitrios, and Luis Miguel Martinez. 2015. "The Role of Accessibility and Connectivity in Mode Choice. A Structural Equation Modeling Approach." *Transportation Research Procedia* 10 (July). Elsevier B.V.: 831–39. https://doi.org/10.1016/j.trpro.2015.09.036.

Polzin, By Steven E. 1999. "Transportation/Land-Use Relationship: Public Transit's Impact on Land Use." *Journal of Urban Planning and Development* december (4): 135–51.

https://doi.org/http://ascelibrary.org/doi/10.1061/%28ASCE%291527-6988%282000%291%3A2%2899%29.

Prasertsubpakij, Duangporn, and Vilas Nitivattananon. 2012. "Evaluating Accessibility to Bangkok Metro Systems Using Multi-Dimensional Criteria across User Groups." *IATSS Research* 36 (1). International Association of Traffic and Safety Sciences: 56–65. https://doi.org/10.1016/j.iatssr.2012.02.003.

Rahman, Saidur. 2008. "Future Mass Rapid Transit in Dhaka City : Options, Issues, and Realities." *World* 6 (June): 69–81.

Soltani, Seyed Hassan Khalifeh, Mashita Sham, Mohamad Awang, and Rostam Yaman. 2012. "Accessibility for Disabled in Public Transportation Terminal." *Procedia—Social and Behavioral Sciences* 35 (December 2011): 89–96. https://doi.org/10.1016/j.sbspro.2012.02.066.

Turcotte, Martin. 2005. "Persons with Disabilities and Employment." *Journal of Social Work in Disability & Rehabilitation*. https://doi.org/10.1300/J198v04n03_05.

Vanany, Iwan, Udisubakti Ciptomulyono, Muhammad Khoiri, Dodi Hartanto, and Putri N. Imani. 2015. "Willingness to Pay for Surabaya Mass Rapid Transit (SMART) Options." *Procedia Manufacturing* 4: 373–82. https://doi.org/10.1016/j.promfg.2015.11.053.

Welch, Timothy F., and Sabyasachee Mishra. 2013. "A Measure of Equity for Public Transit Connectivity." *Journal of Transport Geography* 33. Elsevier Ltd: 29–41. https://doi.org/10.1016/j.jtrangeo.2013.09.007.

Wibowo, Ss, and Piotr Olszewski. 2005. "Modeling Walking Accessibility to Public Transport Terminals: Case Study of Singapore Mass Rapid Transit." *… Eastern Asia Society for Transportation Studies*. https://doi.org/10.11175/easts.6.147.

Zhu, Xuan, and Suxia Liu. 2004. "Analysis of the Impact of the MRT System on Accessibility in Singapore Using an Integrated GIS Tool." *Journal of Transport Geography* 12 (2): 89–101. https://doi.org/10.1016/j.jtrangeo.2003.10.003.

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[1] Geertman and Eck, 1995; Handly and Niemeier, 1997

[2] Ministry of Transport Malaysia

[3] Survey of 106 people at 31 MRT stations

[4] MRT Corporation, Malaysia

[5] Survey data from 2017 and MRT Corporation