Chapter II

Literature Review

This chapter discusses some literatures relevant to this research. The various factors that affect to transit ridership are presented in the beginning, followed by the discussion on the lack of transit ridership, which this research attempt to address. The discussion is then continued with the role of accessibility in transit ridership while walking is the key. The discussion on characteristics and evaluation method of walking as access mode to transit ends this chapter.

2.1 Factors Influencing Transit Ridership

2.1.1 Internal and External Factors

Factors underlying mode choice or mode shifting can be deemed as factors influencing transit ridership. The term of transit that appears in this chapter may refer to all forms of transit, including both bus and train.

The factors related to transit ridership might be organized into internal and external factors. The internal factors are factors that transit authorities can control and manage such as aspects related to fare system, transit capacity and headway, station amenities, and so on. The external factors, on the other hand, are those that beyond the transit authorities' control such as number of population and employment in station area, land use system, and so on. Socioeconomic characteristics are part of the external factors since the authorities are unable to change or to modify the individual characteristics of the transit users.

In the reality, these two groups of factors could not stand separately. They influence each other. For instance, an increase in the number of population (external factor) in station area may change transit demand, which in turn may change the transit level of service (internal factor). However, to understand the role of each factor, most of transit study analyzed internal and external factors separately.

Comparing among internal factors, many studies found that transit riders are more attracted by service improvements rather than fare decreases. For instance, Syed and Khan [9] provided the ranking of factors related to transit ridership in Ottawa-

Carleton area of Canada, from the most important to the least important, as follow, (1) bus information, (2) on-street service, (3) station safety, (4) customer service, (5) safety en-route, (6) reduced fare, (7) cleanliness, and (8) general attitudes towards transit.

Abdel-Aty and Jovanis [10] using transit survey data from Santa Clara and Sacramento California, found that most respondents were satisfied or very satisfied with available transit information. Their estimated binary logit and ordered probit models revealed that ITS-delivered transit information might encourage shifts to transit. Cervero [11] found that the service quality (on-street service and on-board safety) is more important in attracting riders than changes in fares or service frequency.

Kohn [12] found that demand for urban transit services is price-inelastic. Commuters continue to use urban transit services even though fares have increased. The fare increases may be seen as marginal, when compared to the costs of operating automobiles and downtown parking. He used the database of the Canadian Urban Transit Association (CUTA) for 85 urban transit companies from 1992 to 1998.

Comparing internal and external factors, several researchers found that external factors have stronger impact on ridership than internal factors. Chung [13] found the employment and regional development had greater impacts on ridership than did fares, in his analysis of the data of the Chicago Transit Authority (CTA) from 1976 to 1995. Similarly, Gomez-Ibanez [14] found that ridership in Boston between 1970 and 1990 was affected largely by external factors and less by internal factors such as fare changes.

Liu [15] found that external factors (i.e. income per capita, car ownership, suburbanization, and employment locations) had a greater impact on transit demand than internal factors such as fare decreases and service improvements. This research was conducted using US transit data from 1976 to 1990.

Abdel-Aty [16] revealed that lower level of education, younger individuals and low income level are more likely to use transit. The author mentioned as well that lower level of education might mean lower income and hence unavailability of car or only one car per household. While, on the other hand, individuals with higher income are less likely to use transit that might be attributed to safety consideration or also probably a car would be available for the daily trip.

Residential and employment densities have long been considered critical determinants of the transit use (See [17] and [18] for examples). The decentralized residential location and the sprawl of work-related locations are difficult to serve by fixed-route public transportation because transit is most efficient when serving a large number of people traveling to and from concentrated points of activities.

One key point to make mass transit system work is the system should be attractive enough to attract as many passengers as possible. Lacking of this the transit will suffer losses regardless how good internal or external factors applied. Consequently, understanding of transit user's need is necessary. Table 2.1 shows the factor affecting transit use from the transit user's point of view.

Table 2.1 Factors Affecting Transit Use from Users' Point of View

Factors Affecting Transit Use	Descriptions
Service availability, related to location and time	Transit line is relatively close to user's origin and destination and available near the time of users' trip.
Frequency and transit headway	TCRP [19] classified these factors as 'time reliability'.
Punctuality	
Travel time (in-transit time)	Could be considered as *door-to-door* time
Comfort (i.e. walking to and from station; attractive station; boarding/alighting process; available seat; vehicle interior; vehicle temperature; noise; etc)	Defined as an absence of mental and physical strain and the presence of pleasant experience [4]. Walking comfort to access and its environment is classified in this factor.
Convenience (i.e. alternative travel options, information, schedule, parking available, easy transfer, accommodate disabled people)	Aspect of service quality that closely related to comfort. Parking space within transit areas, numbers of feeder and egress modes are included.
Safety on all stage of the trip	Safety refers to absence of accident.
Security on all part of the trip	Security is associated to absence of crime.
User cost	Related to users' out of pocket cost.

Note: This table was summarized from [19] and [4].

2.1.2 Strategies to Increase Transit Ridership

The European Commission Transportation Research, ECTR [20] suggested various strategies to gain more transit ridership which were grouped as direct and indirect strategies. Direct strategies aim to increase efficiency and effectiveness of transit operations and the internal factors of influencing transit ridership becomes their focus. On the other hand, indirect strategies that focus on external factors are generally public policies that influence ridership. Table 2.2 shows the modification of direct and indirect strategies from [20].

Table 2.2 Direct and Indirect Strategies to Increase Transit Ridership

DIRECT STRATEGIES		
PRICING • Fare Levels • Fare Structure • Ticketing Technology • Subsidy Regime	SERVICE PATTERN • Extensiveness of Routes • Distance to/from Stops	INFORMATION • Information Provision • Publicity/Promotion
PRIORITY MEASURES • Link Priority/Right-of-Way • Junction Priority	SERVICE QUALITY • Service Frequency/Travel Time • Operating Hours • Fleet Size • Vehicle Characteristics • Bus/Rail Stop Quality • Interchange Quality • Quality/Number of Staff	OTHER • Park-and-Ride • Integrated Approach
REGULATORY REGIME • Market Regulation • Operational Regulations • Quality Regulations		
INDIRECT STRATEGIES		
CAR OWNERSHIP • Taxation of Car Ownership • Restrictions on Car Ownership	CAR USE, AREA-SPECIFIC • Traffic Calming • Access Restrictions • Road Pricing • Parking Availability and Its Fee in Transit Stop Area • Parking Enforcement	OTHER • Land use Planning, especially within Transit Coverage Areas
CAR USE, GENERAL • Fuel Tax • Restrictions on Car Use • Car Vehicle Specification		

Source: Modified from [20].

Research from some studies indicated that transit ridership increase could be achieved by transportation policies designed to encourage shifting from car to transit. Parking strategies and expansion of transit network in dense areas are two of most effective policies as shown in [13].

As it can be seen in the table, the indirect strategies focus intensively on car use. The encouraging more modes shifting from car to transit become main purpose on those strategies. However, it might not be easy strategies to apply, especially in mass transit strategies in developing countries. Fouracre [1] found that, for developing cities, the majority of beneficiaries of improvement in mass transit (i.e. busway, LRT, and MRT) were likely to be existing public transport users, and that the objective of switching from private car users to mass transit was less likely to be successful. They claimed that no strong evidence of any major switching to busway from private modes, the result which appeared to be similar to those in the advanced countries. The evidence for switching to LRT was not clear either. They argued that most private vehicle users in developing cities come mainly from high income groups who value very high comfort and convenience of personal transport.

Within direct strategies, most of them can be carried out by transit authorities, such as the strategies related to pricing, service quality, and information. Some strategies need to conduct together with transit regulator, i.e. government, such as the strategies of priority measures, regulatory regime, and service pattern.

2.1.3 Other Relevant Issues

Almost all studies related to transit ridership that have discussed previously, focused on mode shifting, especially from private vehicle to transit. Indeed, number of ridership can be gained more by persuading people to use transit more often. Oram and Stark [3] suggested that the infrequent riders are a critical transit market and perhaps the key to build higher transit ridership. This research elaborated the concept of infrequent ridership for mass transit system. Case of mass transit systems of some developing countries was used.

Recently, there is no hard evidence to show direct relationship between station features and ridership. Even so, it is believed that convenience and comfort issues are one affected factors in transit use, as show from the users' point of view. Station features and amenities, as part of transit access and service, can make transit service more convenience and comfortable. Improvement them can escalate transit attractiveness in order to magnetize more ridership.

Some detailed case studies showing increased ridership through improved amenities [21]. Those studies estimated that spending about $450,000 on amenities for a typical transit system could produce a ridership increase of 1.5% - 3%. Amenities improvements included improving waiting environment (i.e. bus shelters, seating, lighting, information, phones, and waste bins) and improving vehicle environment (i.e. driver courtesy, air conditioning, information displays, seating, lighting, and lower floors).

In those studies, no statistics or hard data presented to show how improving features and amenities can increase the ridership. Using another way, the role of station facilities in transit ridership was examined in this research.

2.2 Accessibility Issues Related to Transit Ridership

2.2.1 Concept of Transit Accessibility

Many transit accessibility studies associated to how people with disability access and use transit services. Indeed, the disabilities related to transit accessibility might be in many forms such as financial disability (e.g. cannot afford the transit fare), social disability (e.g. feel unsafe to use transit at night), virtual disability (e.g. unable to access information of the transit service due to language barrier or insufficient information provided), and so on. Since the disability of an individual might differ to others, transit accessibility could come as result of the interaction between transit element and people when they attempt to use it.

Apart from disability and elderly issue, transit accessibility can be distinguished into regional and local accessibility. Number of opportunities that can be reached within reasonable time (or cost as well) using transit is main concept of the regional transit accessibility. This concept can be applied to compare mass transit and other public transportation or between transit and private car for the same pair origin and destination [22]. The deterrence function can be used to express the connection quality that can be derived as the function of travel time or travel cost.

The local transit accessibility is defined as a mode-specific component of regional accessibility, i.e. access to transit. How easy a transit stop to be reached by walking becomes main issue in the many studies related to transit accessibility. In the same manner, the number of destinations that can be reached by 10 minutes walking from transit stop is the main issue in egress trip. Loutzenheiser [23] and Cervero [11] gave good examples of walking to access studies.

Walking is the basic and original mode of transportation and it constitutes important component in the transportation system, especially in public transportation. Result from almost all transit studies revealed that walking is the key. It is the most important access mode to reach transit terminals (bus stop or rail station). The concept of transit accessibility is therefore associated with a certain threshold of walking distance or walking time. Poor transit accessibility often implies that the distance or the time to walk to reach transit terminal are more than these thresholds. The following sections discuss the characteristics of walking as access mode.

2.2.2 Characteristics of Walking as Access Mode

A. Walking Share to Access Transit Stop

Besides walking, there are many alternative modes to access transit stop. Loutzenheiser [23] gave the illustration of the walking access share at some mass transit systems. In BART, Bay Area Rapid Transit (San Francisco), it was found that the proportion of walking to access was only 21% while more than 50% used car. In Tokyo Metro System (Japan), it was recorded that the proportion of walking and using bicycle to access station was 60% and 17%, respectively. Similarly found in The Netherlands that the proportion of walking and bicycle was 30% and 42%, respectively. For the case of Singapore Mass Transit System, it was found that walking was the dominant access mode, around 62%, and then followed by bus and LRT, around 35% [8]. Car and taxi were found rarely used to access station. Note that, unlike other countries, LRT lines in Singapore are operated as feeder mode to MRT lines.

The walking share tends to be decreasing as the distance to transit station increasing while other non-walking mode, especially motorized mode share increases. Figure 2.1 shows the illustration that access mode share varies related to distance from home to station. It can be seen from the figure that walking is most competitive over a short distance.

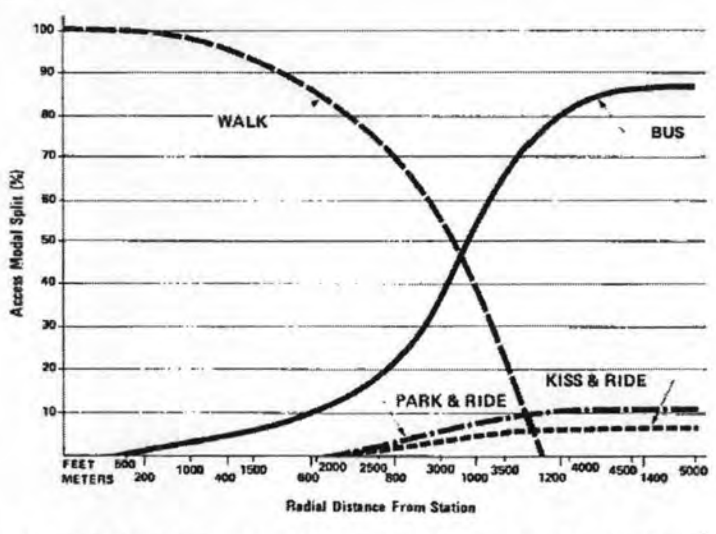

Figure 2.1 Mode Share to Access Station Relative to Distance [5]

B. Walking Speed

According to Allan [24], pedestrians in Australia may be able to maintain a steady walking speed of 6 km/h (100 m/min) for 20 minutes. After 30 minutes, the speed might decrease to 5 km/h and over an hour it will drop to 4 km/h. He noted that 6 km/h for 20 minutes, or 2000 meters, was a reasonable value in many Australian urban environments for walking. It is defined that walking speed of 140 m/min and above was deemed as running [25]. In the walking studies at the CBD areas, in Singapore, it was found that the walking speeds for men and women were 79 m/min and 69 m/min, respectively [26] while, in the case of Bangkok, it was recorded the walking speed of 76.4 m/min and 70.2 m/min for men and women, respectively [27].

Fillone [28] used the walking speed of 76 m/min as the access, egress or transfer mode for the author's study in Metro Manila. It was found for the case of Singapore Mass Transit System that walking speed to access mass transit station for men and women were 76.4 m/min and 71.3 m/min, respectively, while the average was 73.9 m/min.

C. Walking Distance

The walking distance of 400 to 800 meters or walking time of 5 to 10 minutes are often used as the threshold to measure the quality of transit accessibility [6]. Some studies used the maximum acceptance walking distance to define the transit coverage area. However, the exact value of maximum acceptable walking distance seems to vary in the different locations, as shown in Table 2.3.

Table 2.3 Maximum Walking Distance to Access Transit

Location	Transit	Walking Distance (m)	Remarks
Canadian cities	LRT	400-600	General walking distance guidance for LRT [29].
US cities	LRT	457 – 804	General walking distance guidance for LRT [29].
UK	Rail mode Bus	640 390	National Travel Survey 1975/1976 [30].
Brecon (UK)	Bus	Less than 400	Outcome from interview survey (72%) [31].
Scotland	Rail mode Bus	800 400	General walking distance guidance for LRT [6].
Australia	Bus	800	Maximum walking distance to change mode [32]
Singapore	MRT Bus/LRT*	631 192/250	Average walking distance [8]
Mumbai (India)	Rail mode	1,250	85 per cent of access trips [33]
Korea	Subway	732-762	Based on 10 minutes walking [34]
Japan	MRT	360, 540, 720	Related to the grade of station area (cited from [34])

* LRT is operated as feeder mode for MRT

As it can be seen in the table, walking distance to access mass transit relatively longer than to access bus or other feeder modes. For instances, in the case of Singapore, actual walking distances to reach bus stop, LRT station, and MRT were shown in Figure 2.2 while the average walking distance are 192 meters, 250 meters, and 631 meters, respectively [8]. It can be seen in the figure that the distance of 1200 meters is could be deemed as the maximum acceptable walking distance.

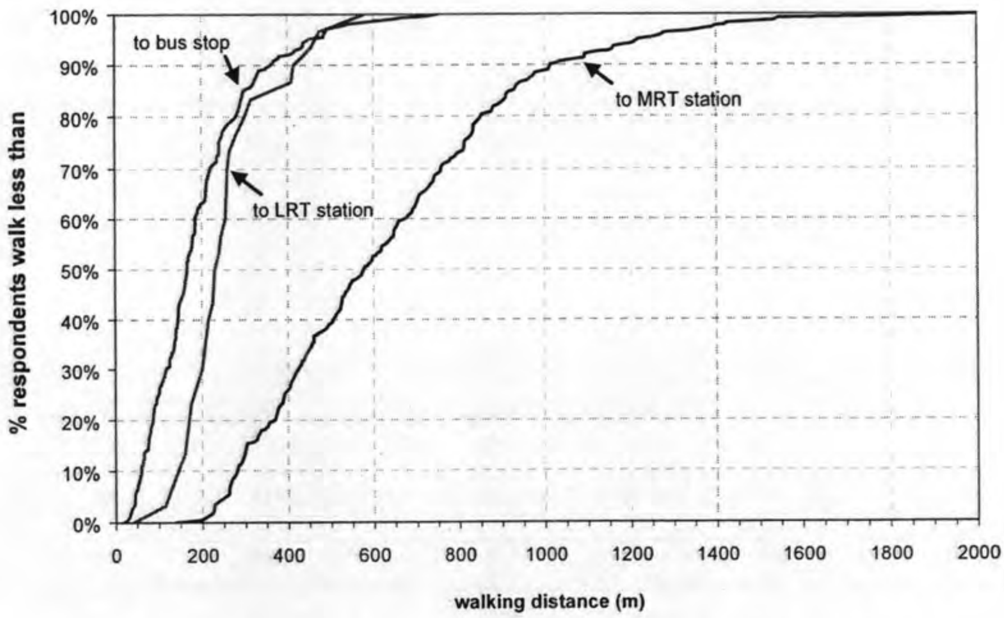

Figure 2.2 Actual Walking Distance to Access Bus, LRT and MRT [8]

D. Modeling of Walking to Access

Modeling of walking to access transit service has been developed by many researchers such as in [34], [8], [11], [23], and many others. An example to show the role of transit user's characteristics in pedestrian access to transit has been done well by Loutzenheiser [23]. The author used data from the Bay Area Rapid Transit (BART) Passengers Survey, which was carried out in 1992, and employed three binary logit models. Some significant findings can be summarized as follows: (1) the most significant variables, those with the greatest effect on the choice to walk rather than other modes to access transit station were walking distance, gender, ethnicity, age, and car availability, (2) the access distance had a negative effect on walking to a station. The longer the distance from a station, the less likely one was willing to walk, (3) men were much more likely to walk than women due to safety and security concerns, (4) ethnicity was significant in the choice to walk. Blacks and Asians were uniformly less likely to walk. Asians in particular were more likely to take feeder bus than walking, (5) those who have age more than 65 years old were less likely to walk. However, senior citizens composed only 4 percent of the survey respondents, (6) car availability was a strong deterrent to walking, (7) similarly that income was most significant to those who drove versus those who walked, particularly among incomes greater than $45,000 per year, and (8) those who have work and school trips were more likely to take feeder bus or drive than to walk.

Cervero [11] also found that built environments (building density, land use type and diversity, transit provision) influenced pedestrian access behavior to rail transit station. The BART data was also used in his study. Apart from walking distance, Olszewski and Wibowo [35] evaluated in more detail the effect of characteristics of walkway along the way to transit station for the case of Singapore. The authors found that probability to walk to reach transit station is influenced by walking distance, the number of road crossing (at junction or at mid-block with or without signal), the number of ascending steps in walkway toward to station (including pedestrian bridge), and the number of traffic conflict (defined as number of car parks and access roads that pedestrians must cross on the way to station). The authors used actual walking distance (network) instead of the presumed walking distance (derived from reported walking time) or straight line distance.

2.2.3 Issue on Walking Accessibility

From the discussion above, it is shown that distance albeit it a very important factor, is not the only determinant for travelers in their decision to walk or not to walk to access transit stop (bus stop or rail station). Travelers' characteristics, physical characteristics, and land use along the walk way have role as well in determining walking to access. Related to ridership, the transit use might decrease as the distance to reach station increases. Zhao et al. [2] revealed that the transit ridership declined exponentially with walking distance to transit stop. However, this study did not yet show clearly the role of the various components within transit station area and station vicinity. Moreover, there are little works on issue of walking to access mass transit station have been done in developing countries, especially in South East Asia region.