DISTANCE, GRADIENT AND BUS SERVICES IN THE CHARACTERISTICS OF COMMUTERS ACCESSING RAIL STATIONS

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ABSTRACT

This paper analyzes the distance and gradient in the travel characteristics of commuters using rail transit for their journey to work with specific focus on the utilization of public bus as a feeder to the station. The study is based on the public responses collected from questionnaire survey distributed to residential areas in Hidaka City, Japan. The access trip characteristics to the station are examined in terms distance and gradient with concentration on the provision of the public bus as a feeder. Mode use pattern, distance and gradient from home to the station and to the bus stop, and satisfaction to the bus services were evaluated and discussed. It is expected that the underlying preferences of commuters in accessing transit stations can be understood to provide better policy in improving the public bus and rail transit ridership.

Keywords: public transport, small city, accessibility, rail station, Japan

1. INTRODUCTION

Accessibility to rail station has a crucial role in the propensity to use rail. A journey by rail should be viewed as a chain of journey or a door to door journey to make the railway a viable and attractive alternative to the car (Givoni and Rietveld, 2007; Brons et al., 2009). Therefore, integration with different modes of transportation to and from the station should be considered as a whole part of the journey. Moreover, the choice of departure station for a passenger is also affected by the accessibility of the station (Debrezion et al., 2009). A study in the Netherlands rail passengers by Brons et al. (2009) even proved that accessibility is more important for infrequent travelers which indicate that improving the access to the rail network will potentially increase their use and can attract new patronages. This can be a good policy option for improving the transportation system in shifting private car users to public transportation. The same study also concluded that once a rail service is provided at a certain area, improving the service and improving the access to it are substitutes when it comes to increasing rail use. However, the latter is probably more cost effective and feasible, especially under budget constraints. The justification is stronger for the choice of improving the access to the station when it comes to areas where the level of rail service is relatively low.

Rail transportation system is the second popular transportation means for commuting in Japan after private cars (Statistics Bureau, 2009). Access to and egress from rail stations are usually done by intermediate modes such as walking, cycling or kiss and ride. This situation is quite different compare to developing countries, where, in most developing countries, people can rely on paratransit, such as rickshaw, jitney, motorcycle taxi or bicycle taxi, for a short distance travel, including to a rail station. The option of paratransit in Japan is limited only to taxi which can be categorized as an expensive alternative, even for Japanese. Therefore, public buses are the common affordable access and egress mode to rail stations, especially for transportation disadvantage people and those who live outside the walking or cycling distances from the station or without a private vehicle in the household.

This study analyzed data collected from Hidaka City in Japan. As the city is a small city where the level of rail service is relatively low, improvement of the access to the station is expected to be effectively and efficiently increase the rail use. To be more specific, a study by Givoni et al. (2007) using data set from the Netherlands revealed that connections with public transport were the most important access facility. The public bus is the only available public transportation in Hidaka City so the improvement should focus on the improvement of service quality of the public bus. Additionally, the improvement of public bus is expected to encourage people to leave their car and shift to the public bus which will reduce air and noise pollution and benefit the community as a whole. In order to achieve this, it is necessary to understand the travel characteristics of rail passengers related to the usage of public bus. The objective of this article is in this line with focus on two aspects in analyzing the characteristics: distance and gradient in accessing the rail station in relation with the public bus as an intermediate mode. The study covers only working commuters who use rail service to reach their destination. The findings are expected to be useful to help set policies and strategies in improving the accessibility and the target group. This research is different from the available research studies in two aspects: i) the scope of the research is limited to one city, not on nationwide data as the coverage of most available research in this subject, ii) the study area is a small city which has not been the focus of many research studies in this field. Most studies usually use case study from a big or a metropolitan city. With these distinctions, it would be interesting to know how the results may differ from available studies. The results are also expected to produce reference on the acceptable walking and bicycling distances in the context of Japan.

The next section briefly explains the study area and the data for this study. Section 3 examines the distance aspect which consists of the distance to the rail station and the distance to the bus stop. In Section 4, the aspect of gradient is investigated. The evaluations of public bus services are discussed in Section 5. Finally, some important findings of the study are presented.

2. THE DATA

Hidaka City is a small city located in the southern region of Saitama Prefecture, a prefecture adjacent to Tokyo Metropolitan Area. The city has inhabitant of around 54,901 people with an area of 47.5 km^2. The city is located in hilly area and the area under study is topographically situated between 20 and 105 meter above sea level. The study area is limited to three major residential neighborhoods in the city, which are served by two rail stations that are connected to each other. The first residential area is Hidaka-danchi which is close to Musashi Takahagi Station and the other two are Naka Kayama and Komagawa-danchi which are adjacent to each other and in close proximity served by Komagawa Station. The longest public bus route operated from Hidaka-danchi to Hanno Station which is another rail station located in Hanno City and operated by different rail operator and serving different direction from the first two stations. Figure 1 illustrates the study area.

Questionnaire survey as part of a project to increase the ridership of the public bus was conducted in August 2006. The questionnaires were distributed to all households in the study area which is made of 4,584 households. Each household received two commuter questionnaires to anticipate that one household may have more than one breadwinner. In total, 663 filled questionnaires were received (7.2% return rate). However, valid responses are limited to 587 questionnaires and within this amount, only 265 respondents are rail commuters.

Figure 1 - The study area

More than half of the respondents (55%) are in their productive age of 18-49 years and majority of them ride a bicycle or a bus to the rail station. Some elderly people (65 years and above) were still working even they have passed their retirement age. This age group composed of nearly 8% of the sample and almost half of them use the public bus to go to the rail station. The last age group (50-64 years), which can be categorized as nearly retirement age group, is dominated by public bus users but the degree is not strong enough to cover half of the group (36%). The distribution of travel modes by age categories is illustrated in Figure 2. The figure strongly shows that the public bus is a favourite feeder mode among rail commuters regardless their age, followed by bicycle and walking. There is no elderly respondent drives a private car or rides a motorcycle to the rail station. Their age which affect their vision and reflect may hinder them from safely drive a private car and more over ride a motorcycle.

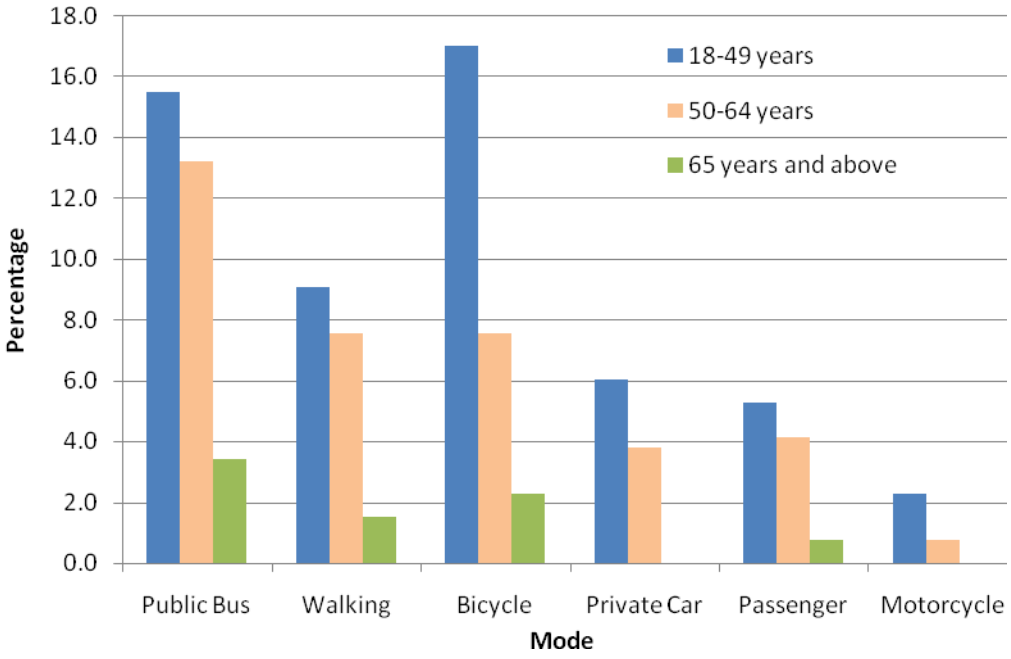

Figure 2 - Distribution of travel modes by age categories

3. DISTANCE

3.1 Distance to the Rail Station

The distribution of the modes used to access the rail station based on the distance from home to the rail station is displayed in Figure 3. This distance is the measured distance on the map. Every questionnaire was coded based on the location of the household where it was distributed so the home-end of each respondent can be easily traced. The station is the destination station of each respondent as stated in the questionnaire. With this O-D information, the distance between home and the rail station was measured using online service map. The distance used for walking mode is different from other modes as available shortcuts were considered when measuring the distance so, in general, the distances are shorter than the distances used by other modes.

From the cumulative percentage in Figure 3, it can be observed that walking and bicycle are mainly use for commuters who live around 2 and 2.5 km, respectively, from the rail station. This walking distance is higher than the acceptable walking distance found from studies in San Francisco, US (Cervero, 2001, where 1 km is the threshold), in Mumbai, India (Rastogi and Rao, 2003, where 1.25 km was set as a boundary line), and in Toronto, Canada (Stringham, 1982, where nobody walked farther than 1.75 km to reach a station). The distance for bike and ride was considered low. Bicycles are supposed to be a substitute for walking when distances increase. For comparison, a study using data from three European countries suggested a catchment area up to 4 or 5 km for the same type of rail system (Martens, 2004). The Mumbai's study (Rastogi and Rao, 2003) also found that the

acceptable distance for bicycles was around the same figures as the lower range of the three European countries.

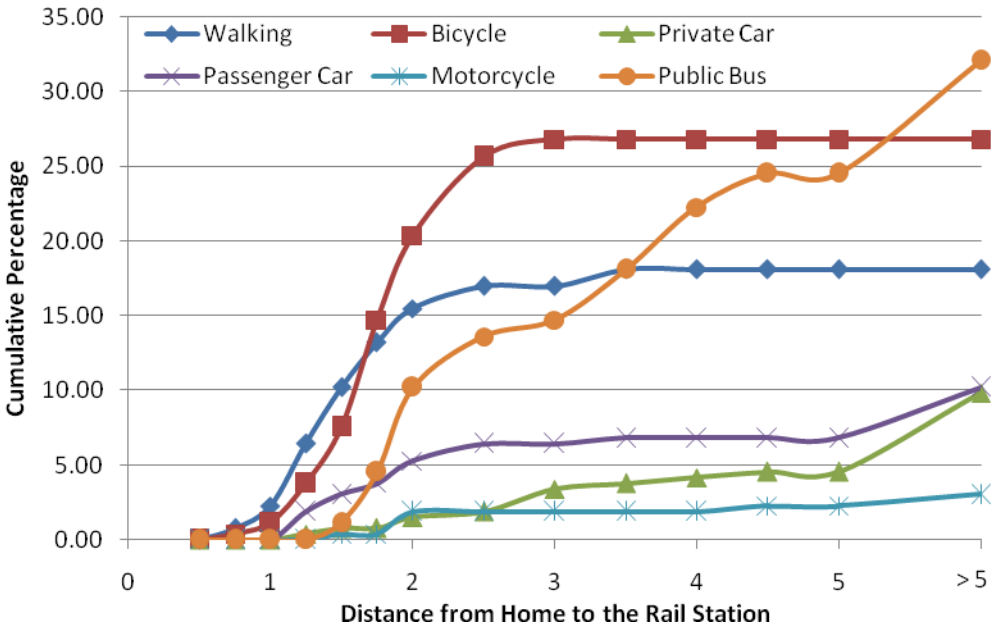

Figure 3 - Distribution of access mode by distance from home to the rail station

There are no pattern can be concluded for private car and passenger car. Kiss-and-ride rail commuters can be found within a short distance from the station, even a very small number of commuters drive their car to the station in this distance. The share of both modes increase drastically when the distance from the rail station is further than 5 km with the magnitude for the private car is higher than the passenger car. Homes of public bus passengers spread out with distance but not less than 1 km from the station. Almost 32% of bus passengers live between 1 and 2 km from the station. This may be due to the reason that commuters who use rail for commuting prefer to live close to the rail station. This mode is also relatively popular for distance above 3 km. It should also be noted that nearly a quarter of bus users live beyond 5 km from the station so patronages of the public bus are quite disperse in distance.

As this study examine the travel characteristics of rail commuters with focus on public bus as a feeder, the rail commuter data is then categorized to regular bus user, irregular bus user and non bus user so analysis can be carried out to map the travel characteristics based on these groups. Irregular bus users are passengers who usually use travel means other than the public bus to reach the rail station but they occasionally ride the public bus especially in certain situations, such as when it is raining or when the private vehicle is not available. Meanwhile, non bus users are commuters who use other modes of transportation except the public bus to reach the rail station, regardless of what the situation is. Figure 4 presents the number of respondents in each category and its relevant mode shares.

With the above categorization, the walking distance to the rail station was examined based on each category. The result is presented in Figure 5. There are outstanding numbers of

irregular users and non users living between 1 and 2 km from the station, which can be explained with the dominant shares of bicycle and walking for these two categories. All bicycle and walking commuters for the non user category live within 3 km from the rail station. A similar situation is also applicable for the Irregular User category; only the distance is extended to 4 km for a few pedestrians. Slightly more than ten percent of the Non User category are private car drivers who live farther than 5 km from the station which represent around two third of the Non User category in this distance range and also in the private car mode.

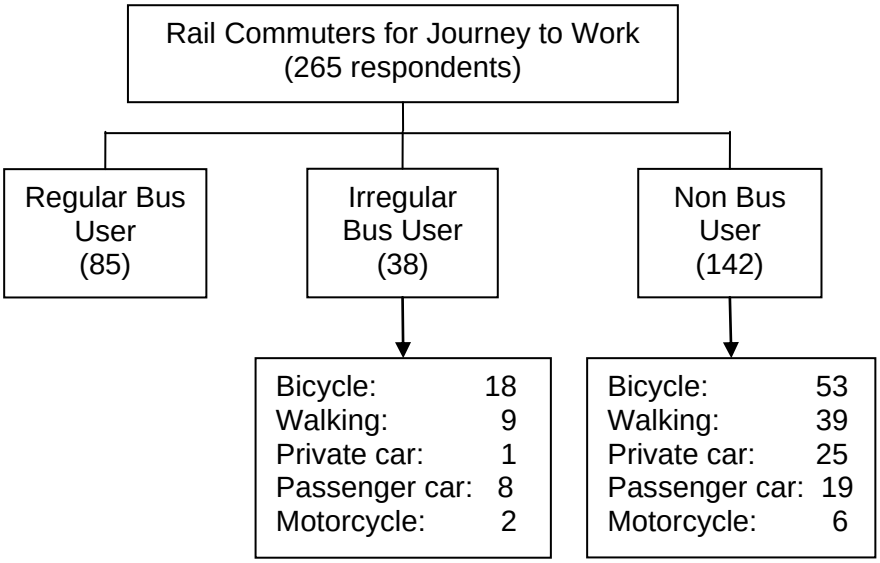

Figure 4 - Categorization of rail commuters for journey to work

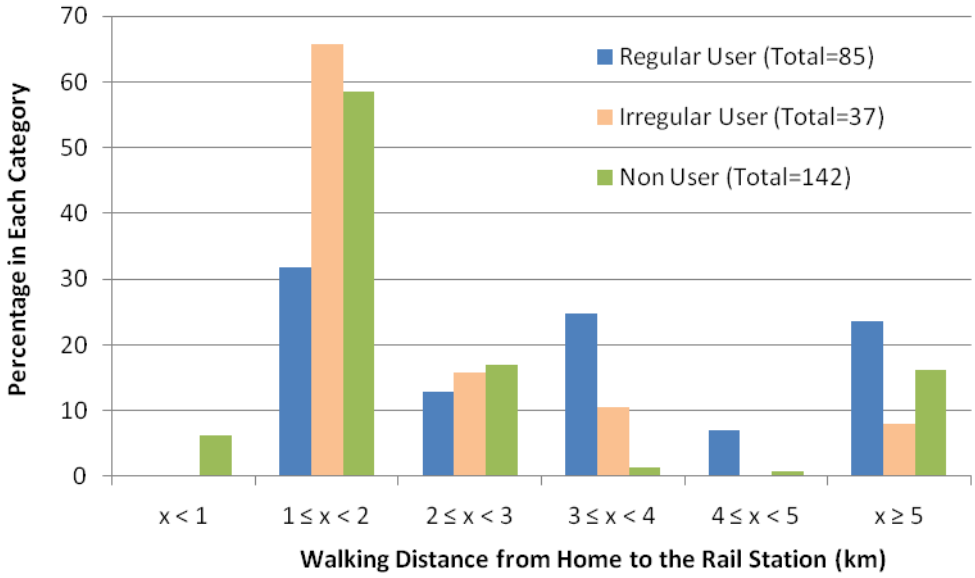

Figure 5 – Walking distance from home to the rail station for each category

When more detailed analysis was performed on the walking distance by considering the age group of commuters in each category as shown in Figures 6-8, it was found that for the

Irregular User and Non User categories, there are high concentration of productive age and nearly retirement age groups live in the distance between 1 and 2 km with the magnitude of former group almost double the latter group. The situation is rather different for the Regular User category where concentration of users over the distance was relatively not so exceptional. It is true that the majority of the all group ages live between 1 and 2 km from the station but the amount is not significantly outstanding. In this category, the nearly retirement age group is slighly higher than the productive age group for the discussed distance. Homes of the elderly age group who is regularly ride the public bus to the station are quite disperse in distance from the station. Meanwhile, for the other two categories, elderly commuters mainly live within 2 km as most of them rely on their feet and bicycle to reach the station.

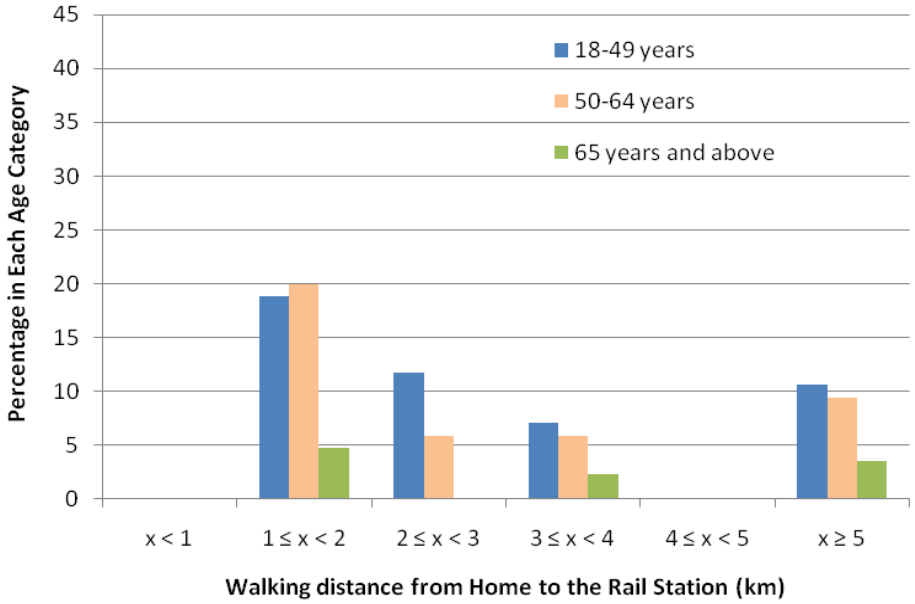

Figure 6 – Walking distance from home to the rail station for Regular User

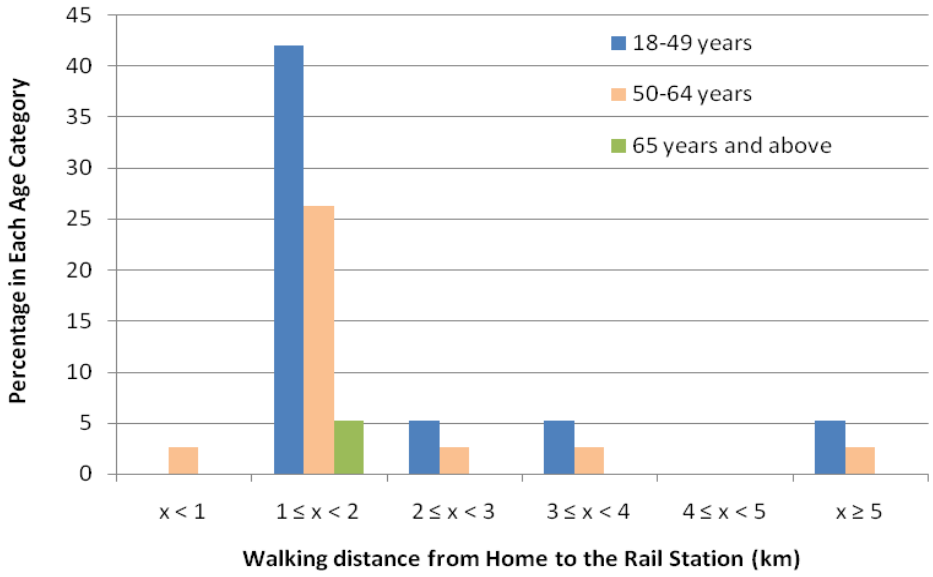

Figure 7 – Walking distance from home to the rail station for Irregular User

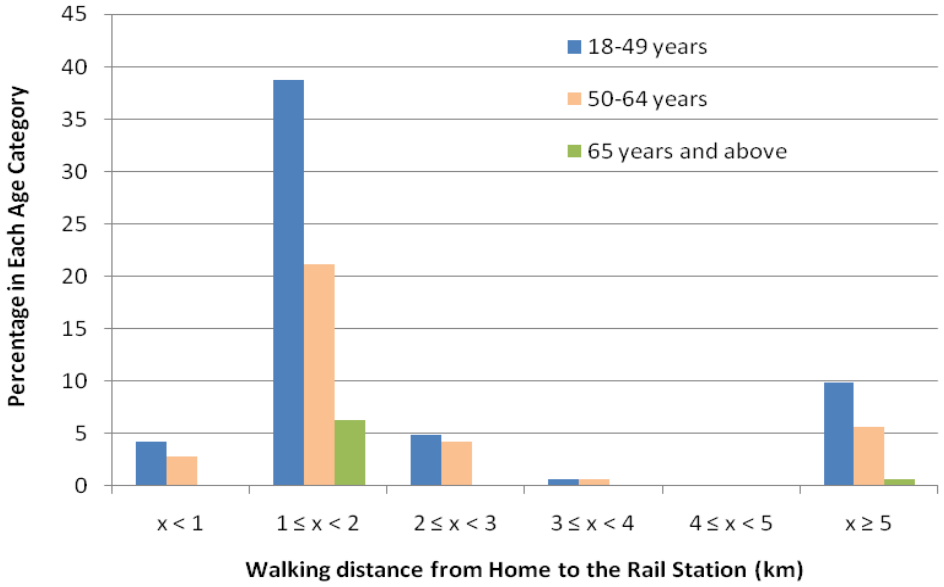

Figure 8 – Walking distance from home to the rail station for Non User

3.2 Distance to the Bus Stop

As walking distance to the bus stop is one of the important factors that influence people to use the public bus, the walking distance between home and the nearest bus stop of the respondents is examined. Figure 9 shows the share of respondents in each category of user based on the walking distance to the bus stop. It was found that from 100 m distance to the bus stop, the number of regular bus users is decreasing by distance. However, there are no regular users live more than 500 m from the bus stop. The same trend also applies for Irregular User category but not for Non User category as for this category, the number is higher for distance more 500 m than the previous 200 m. Interestingly, the percentages of irregular bus users and non bus users live less than 100 m from the bus stop are higher than the regular bus users. The results indicate that distance to the bus stop does influence people tendency in regularly using the public bus. Distance to the bus stop should not be an issue in the study area as around 70% of the respondents live within 400 m from the bus stop, the distance that most passengers willing to walk to bus stops (O'Sullivan and Morrall, 1996, TRB, 2003). Considering that people may tend to walk shorter distance in hilly area, then the locations of the bus stop are conveniently accessible (within 300 m) for 55% of the respondents. This was confirmed by the response of respondents in which 78% of them consider that the bus stop location is good and quite good.

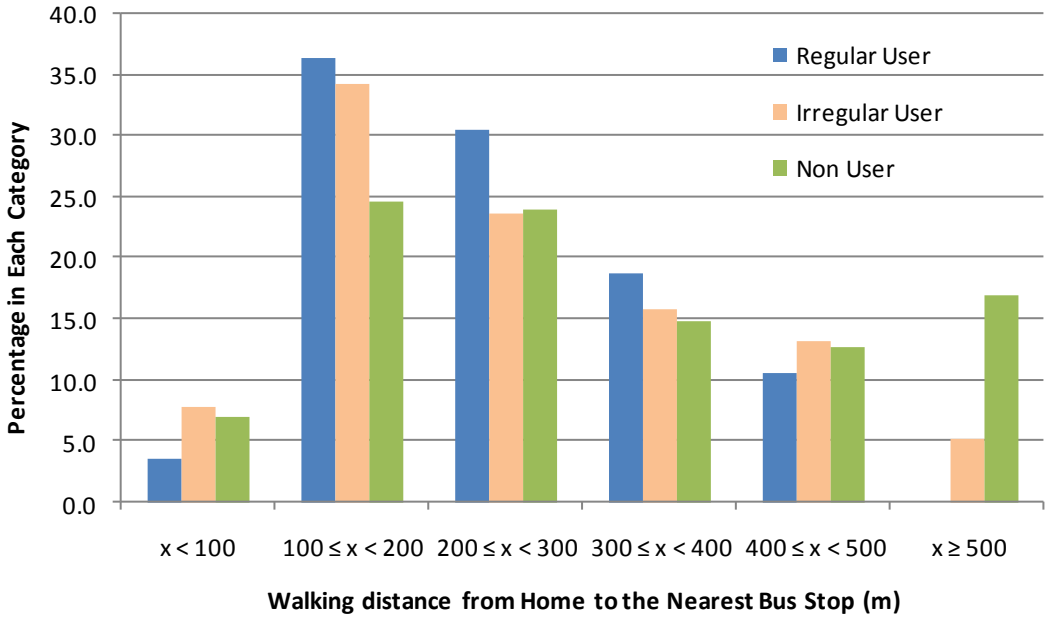

Figure 9 – Walking distance from home to the nearest bus stop

Even the patronage of the public bus resides until a half kilometre from the bus stop, the distance that considered appropriate by majority of respondents is less than that. Table 1 shows the approximate actual distance and walking time as claimed by respondents and the appropriate distance and walking time to the bus stop solicited from respondents. The comparison of these two perspectives reveals that the average claimed distance and time is lower than the average appropriate for all categories. The comparison implies that, on average, passengers actually walk to the bus stop shorter than the appropriate distance and time. This suggestion strengthens the finding on the previous paragraph and provides additional reason why most respondents consider that locations of the bus stop are not an issue. The mode values also have the same tendency especially for Regular User and Irregular User (with exception for the distance which is the same). There are two mode values for the appropriate distance suggested by Non User category. Both of them are lower than the actual distance, even the mode for the waiting time is the same. This may be because of the low approximation of the appropriate distance associated to the suggested time.

As the distance and time claimed by passengers are mostly based on passengers experience and intuition than actual measurement, the distance measured from the map with its corresponding walking time calculated using average walking speed of 80 m/min are provided in Table 2. The average measured distances are higher than the claimed distances for all categories, with the Non User has the highest difference. Again, the highest difference may be related to the familiarity in translating how many minutes walk equivalent to how many meters, especially this category of users have never used the public bus for their commuting purpose so familiarity with the distance and time may be an issue, especially the distance. The argument on Non User is reasonable since the comparison of the walking time tells different story as the average measured times are only slightly lower than the claimed

walking times for all categories. As also suggested by one study (Hine and Scott, 2000) that people who use the public transport to go to work had a noticeably different attitude to time and waiting for a service. They were able to plan their journey so that waiting time could be minimised. To achieve this, of course, they should know how many minutes approximately it takes to walk to the bus stop or to the rail station. The walking time seems to be more reliable reference as it is usually easier to describe the distance in terms of time than the actual distance. Another apparent observation from the comparison is that the maximum measured distances are lower than the claimed maximum distances also for all categories, especially for Irregular User and Non User categories which is around half.

From the above observations, therefore, it is more reliable to refer to the time when acquiring information from the survey. Thus, a 5 minute walking time can be determined as the appropriate walking time. With an average walking speed of 80 m/min, the distance is 400 m which is higher than the proposed approximate distances. When this walking distance is compared with the walking distance to the rail station of 2 km, it was more than five time higher, not double as suggested by O'Sullivan and Morrall (1996). When the average walking distances for both destinations are used, the result was even higher, with a figure of almost seven. However, it should be noted that this study covers only working commuters, not the overall trips using the public bus and the rail as in their study.

4. GRADIENT

As the study area is located in the hilly area, the effect of terrain was also analyzed by considering the gradient. The gradient is calculated as the percentage of the difference in the elevation between two points divided by the distance (grade of 1% means one meter climbed for every 100 meter horizontal distance). Unfortunately, the gradient between home and the rail station cannot provide any insight as the gradient is relatively low due to the long distance with the highest gradient is less than 2%. This is also the possible problem with the gradient between home and the rail station as it could not grab the possible locality factor of high terrain that may exist. A study using the same data on the influence of this gradient in deciding the modal to the rail station also showed no explanatory power provided by this variable (Santoso et al., 2009). To anticipate the locality factor, the gradient between home and the nearest bus stop can be used as a proxy to find out any locality in the terrain. As the study area is a small city, it is reasonable to expect that there is not so many ways to go the rail station so the road used to go to the public bus is very likely to be the same road used by commuters to go the rail station on foot, by bicycle or by car. The gradient is classified into three: i) relatively flat when the absolute gradient is less than 5%, ii) steep when the absolute gradient is between 5% and 8% and iii) very steep for the absolute gradient equal and above 8%. The classification is partially based on the study related to the relationship between walking speeds and grades as available in the manual published by Transportation Research Board (TRB, 2003), where at grade above 5%, the distance that can be travelled within 5 or 10 minutes diminishes. Figure 10 illustrates the distribution of commuting mode based on the gradient between home and the nearest bus stop.

Table 1 – Comparison of actual and appropriate walking distance and time to the bus stop

Category	Approximate Actual as Claimed						Appropriate					
	Distance (m)			Walking Time (min)			Distance (m)			Walking Time (min)		
	Average	Max	Mode	Average	Max	Mode	Average	Max	Mode	Average	Max	Mode
Regular User	202.4	600	200	3.3	7	2	260.3	1000	300	4.5	10	5
Irregular User	246.2	1,000	300	3.4	8	3	290.0	1000	300	4.4	10	5
Non User	237.9	2,000	300	4.3	25	5	242.8	1000	100 & 200	4.9	20	5

Table 2 – Walking distance and time to the bus stop measured from the map

Category	Measured from the Map			
	Distance (m)		Walking Time (min)*	
	Average	Maximum	Average	Maximum
Regular User	252.9	495	3.2	6
Irregular User	246.9	573	3.1	7
Non User	312.9	798	3.9	10

*Note: * Walking time is calculated from the distance with average walking speed of 80 m/min*

More than 80% of respondents live on the relatively flat area, while close to 15% lives in a proximity to the bus stop with a steep slope. Almost all pedestrians and cyclists reside on the flat area. Surprisingly, most of those who live with a steep slope to the bus stop are regular bus users. They, including those who live with very steep slope, represent 40% of the total bus patronage. The high percentage of bus users with steep and very steep gradient between home and the bus stop indicates that the gradient does not discourage people to walk to the bus stop, at least for this case study. The expectation that many car users and passengers live in the steep area was not proven.

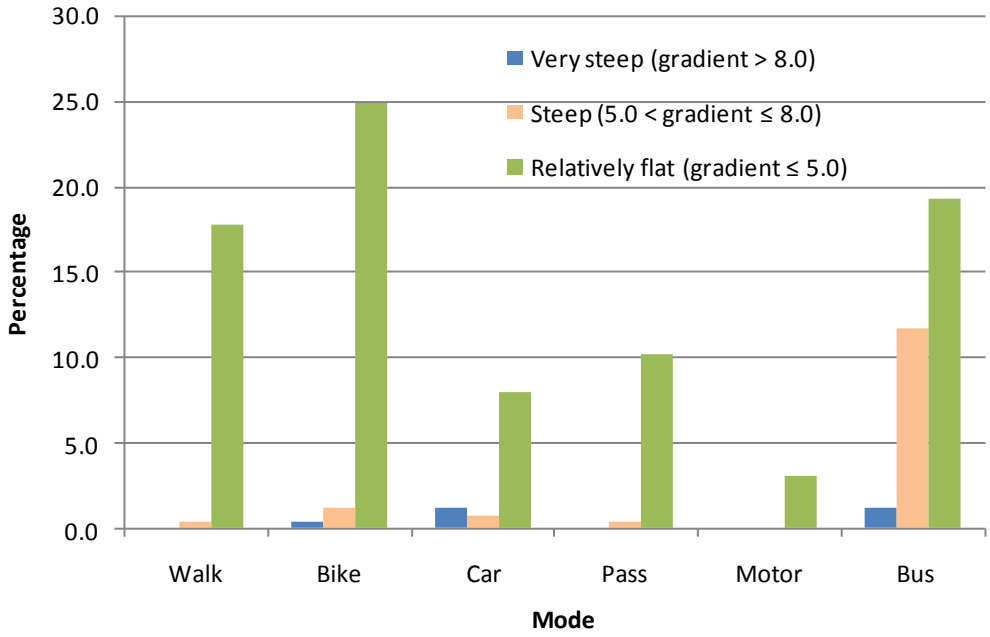

Figure 10 – Distribution of travel mode by gradient (%) between home and the nearest bus stop

5. PUBLIC BUS SERVICES

Since smoothness of transfer from the public bus to the rail and vice versa, and the punctuality of the service itself significantly influence the waiting time for passengers, these two factors were also inquired in the questionnaire. The evaluation on the transfer is provided in Figure 11 (no idea and missing data are not included). The evaluations from Regular User category are in agreement with the evaluations from Irregular User categories that the transfer from the public bus (PT) to the rail is considered acceptable for most of users but not for the reverse direction. The gap between satisfaction and dissatisfaction of the transfer for both directions is relatively high for regular users. The same tendency was also shown for irregular users but only for assessment from the rail to the public bus in which mostly are dissatisfied. The gap between irregular users who think that transfer from the public bus to the rail is satisfactory and unsatisfactory is relatively small.

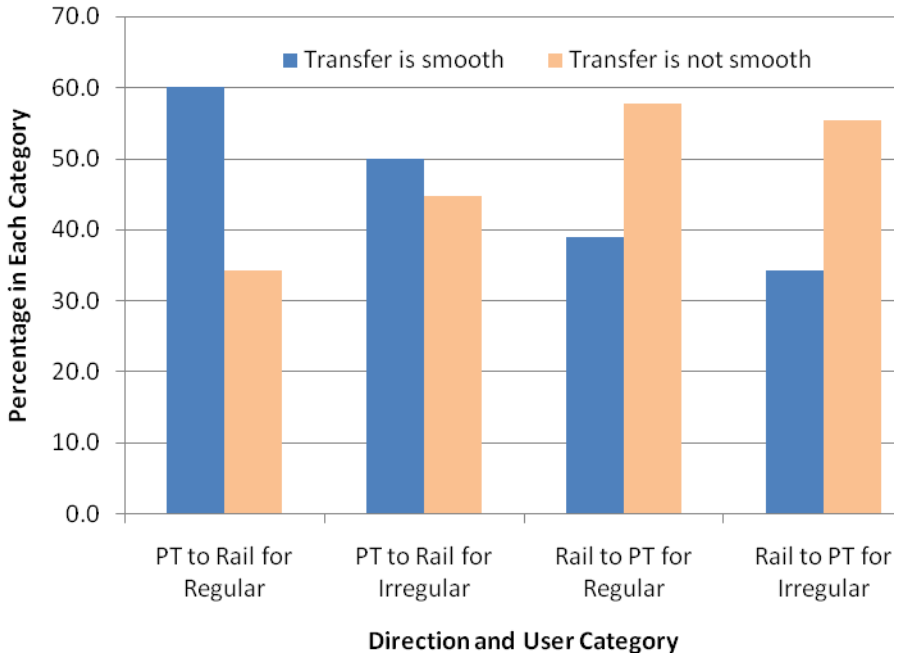

Figure 11 – Evaluations on transfer from the public bus to the rail and vice versa

The opinion on the punctuality of the public bus is presented in Figure 12. Again, there are much less passengers from the Irregular User category consider the service is reliable than the Regular User category. Passengers were quite concerned with the delay of the service during bad weather days, especially for Irregular User category as this category of users shifts their modes to the public bus in this situation so they were more exposed to experience delay than the Regular User category. However, if the delay due to bad weather is considered acceptable delay then more than 60% of users in each category were satisfied with the punctuality of the service.

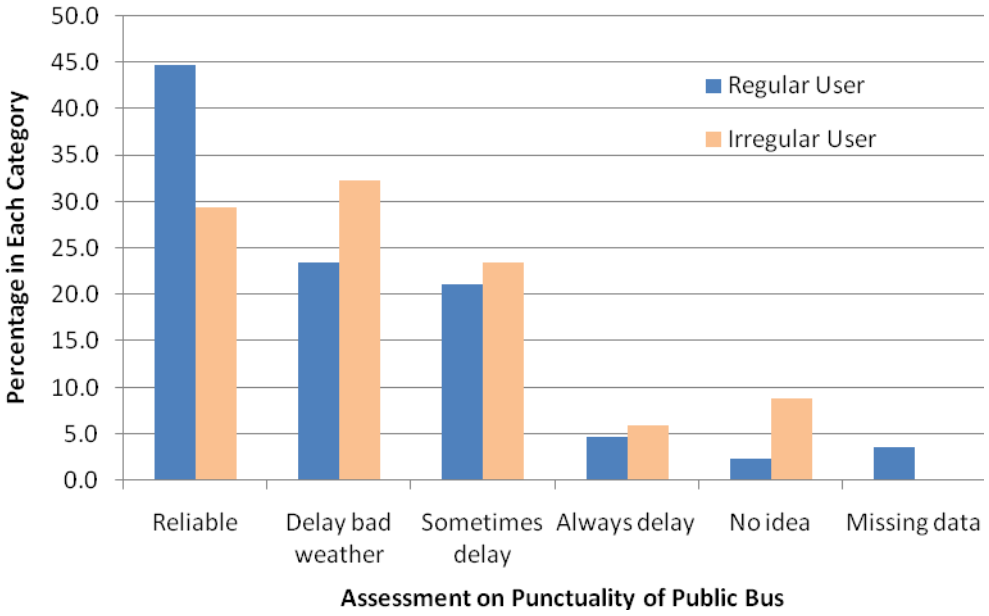

Figure 12 – Assessment of punctuality of public bus

The above evaluation results may indicate that irregular users relatively give higher value of time than regular users. That may be one of the reasons why they prefer not to use the public bus as their frequent mode to avoid the idling time of wait.

Reasons for not (regularly) using the public bus to the rail station were explored to commuters in the categories of Irregular User and Non User. Respondents can choose more than one reasons provided in the questionnaire or fill their own specific reasons. The result is presented in Figure 13. It was found that majority of commuters claimed that frequency of bus service and short operation hours of the bus are the main reasons deterring them to use the public bus. Reason of 'Others' is an open reason which was filled personally by respondent. This reason was the third major excuse for both categories. There were two excuses mostly filled by respondents. One was that the distance to the rail station is quite close so they prefer to walk or cycle to the station. The second one was some respondents prefer to walk or ride bicycle for heath purpose instead of using the public bus. Figure 13 also shows that Non User category was more concerned about the bus service hours, cost and location of bus stop than the Irregular User category. Other reasons more or less have the same magnitude for the two categories.

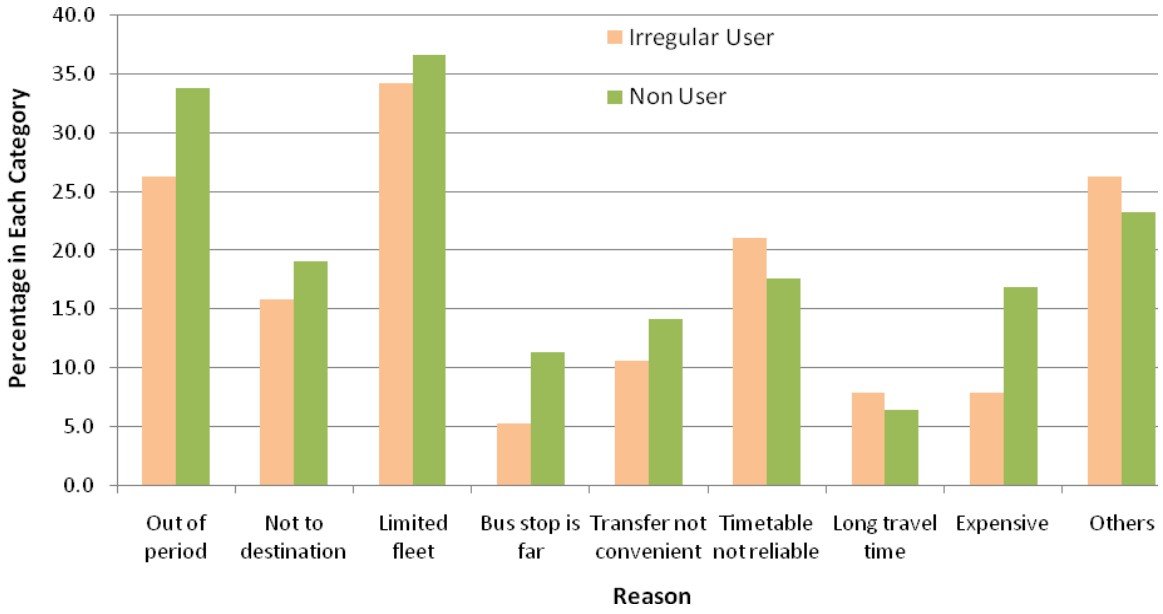

Figure 13 – Reason for not using the public bus to the rail station

6. CONCLUSIONS

Examination on distance and gradient in the travel characteristics of commuters who board on the rail for their journey to work was conducted in Hidaka City, Japan. The city is a small city located in the mountainous area. The study focuses its analysis on the provision of the public bus as a feeder. The data was collected from questionnaire survey distributed to three

main residential areas in the study area as part of the efforts to increase the ridership of the public bus.

The examination showed that the public bus was the most favourite mode to reach the rail station for commuters above 49 years old. Productive age commuters (18-49 years) mostly prefer to cycle to station with the public bus as their second priority. More than 40% of passengers regularly ride the public bus to the station live within 2 km from the rail station. Unfortunately, the percentage of non bus users live within the same distance is higher than the above category (more than 70%). With an acceptable walking and cycling distance to the rail station at 2 and 2.5 km, this indicates that the share for possible increment in the ridership of the public bus is not much. Additionally, some commuters think that walking or cycling is a good exercise for their health than just sitting on a bus.

The walking distance to the bus stop was not an issue in the study area. On average, the walking distance was less than the appropriate walking distance suggested by respondents, which is 400 m or 5 minutes walking time. It should also be noted that the ratio of the acceptable walking distance from home to the rail station and to the bus stop was more than double. Bus operator should anticipate this in estimating the bus ridership so the figure is not over forecasted. This long walking distance can be considered as specific to Japanese case only. The gradient in the study area did not seem to be a deterrent for walking as 40% of regular bus users live with a steep slope from the bus stop.

There was a tendency that irregular users of the public bus assign higher value of time than the current bus users. Therefore, improvement of the transfer time, especially from the rail to the public bus, and maintaining the bus schedule, especially during bad weather can be expected to attract more frequent users of the public bus. Finally, if it is financially feasible, increasing the number of fleets and extending the operation hours would be the necessary ways to attract new patronage for the public bus.

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