A Quantification Method of Attractiveness of Stations and an Estimation Method of Number of Passengers Taking into Consideration the Attractiveness of the Station

Naoya Ozaki, Takuya Watanabe, Ryosuke Matsumoto, Noriko Fukasawa

Abstract—In the metropolitan areas in Japan, in many stations, shopping areas are set up, and escalators and elevators are installed to make the stations be barrier-free. Further, many areas around the stations are being redeveloped. Railway business operators want to know how much effect these circumstances have on attractiveness of the station or number of passengers using the station. So, we performed a questionnaire survey of the station users in the metropolitan areas for finding factors to affect the attractiveness of stations. Then, based on the analysis of the survey, we developed a method to quantitatively evaluate attractiveness of the stations. We also developed an estimation method for number of passengers based on combination of attractiveness of the station quantitatively evaluated and the residential and labor population around the station. Then, we derived precise linear regression models estimating the attractiveness of the station and number of passengers of the station.

Keywords—Attractiveness of the station, estimation method, number of passengers of the station, redevelopment around the station, renovation of the station.

I. INTRODUCTION

IN the metropolitan areas in Japan, multiple railway operators compete against each other on very dense railway network. Given the proximity of lines and stations, there is often overlapping catchment area of stations (Fig. 1). In addition, in many stations, shops, service facilities, escalators, and elevators are installed. In many areas around the stations, there still have been many urban renovation projects in some major urban areas.

In areas with many railway lines such as urban areas where passenger can choose the line to use, railway operators may want to raise the attractiveness of their stations for the sake of promoting the ridership of their lines.

Several studies [1]-[4] are already done to define station catchment areas, but elements other than railway services are not considered. Various studies [5]-[7] have also carried out to estimate the number of passengers at stations, but none of them relate the attractiveness of stations and their passenger volume. Therefore, in this paper, we examined the method of quantifying the attractiveness of stations regarding the facilities in and around the station, in addition to the level of the railway

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service itself, and the method of estimating the number of passengers using the attractiveness of the station.
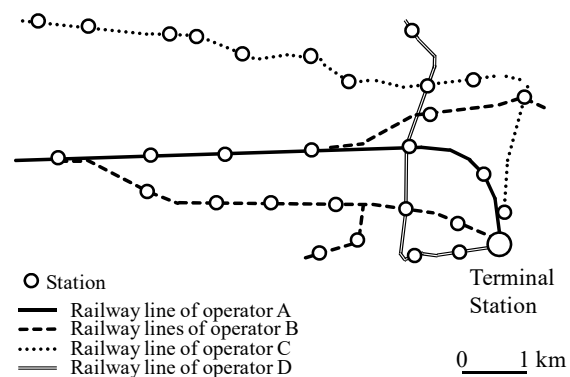

Fig. 1 Railway map of a part of Tokyo metropolitan area

II. QUANTIFICATION METHOD OF ATTRACTIVENESS OF STATIONS

In this section, we summarize the methodology and the results of the Web questionnaire survey conducted to develop the method of quantifying the attractiveness of the station, and the verification results of the developed method.

A. Questionnaire Survey

The area covered by the questionnaire survey is two metropolitan areas where multiple railway operators compete. In order to investigate the usage of the lines, stations and facilities around the stations, persons with multiple stations available from their home are considered as survey samples. Furthermore, in order to target the people who use the railway constantly, samples who use the railway at least once a week and who are over the age of 15 were incorporated. Questions include the convenience of the station, the convenience of the facilities and services the station and around the station they constantly use. Details of the questions are shown in Table I. We collected 2613 responses in region A and 1022 in region B.

B. Developing Quantification Method of Station Attractiveness

First, regression analyses, responses for each factor as shown in Table I being explanatory variables and the overall evaluation of station attractiveness also obtained in the

questionnaire being the dependent variable, were conducted. An example of the regression equation for Region A obtained is shown in (1):

Attractiveness of the station =
0.093 * vending machines are present on the platforms
+ 0.086 * shops are present in the station
+ 0.111 * information center is present in the station
+ 0.081 * bookstores are present in the station
+ 0.260 * inside of the station is clean
+ 0.164 * restrooms at the station is clean
+ 0.199 * platforms are wide + 0.064 * many trains are departing
+ 0.063 * express/faster trains stop
+ 0.326 * nursery school or kindergarten is present
+ 0.217 * retail stores are substantial around the station
+ 0.286 * commercial facilities are substantial around the station
+ 0.079 * tourism facilities are substantial around the station
+ 0.141 * taxi stands are substantial around the station
+1.039 (constant)
(1)

An example for Region B is shown in (2):

Attractiveness of the station =
0.129 * shops are present on the platforms
+ 0.137 * supermarkets are in the station
+ 0.195 * barbers or beauty salons are in the station
+ 0.338 * inside of the station is clean + 0.115 * platforms are wide
+ 0.085 * many trains are departing
+ 0.225 * retail stores are substantial around the station
+ 0.362 * commercial facilities are substantial around the station
+ 0.092 * entertainment facilities are substantial around the station
+ 0.170 * bus stops are fulfilling around the station
+1.641 (constant)
(2)

supermarkets, barbers, or hair salons in the station. Regarding the railway service, attractiveness has the relationship with the cleanliness of the station, the width of the platforms and the number of trains. Regarding the area around the station, relationships with the presence of retail shops, commercial facilities, entertainment facilities, and bus stations were observed.

TABLE I
ITEMS ASKED IN THE QUESTIONNAIRE

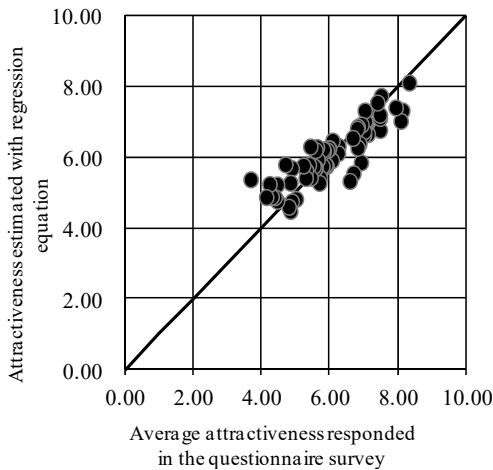|	
about stations	station closest to the home, destination station in commuting, attractiveness of frequently used station (on a zero-to-ten scale)
presence of facilities in the station	waiting rooms, shops, vending machines, restaurants, escalators and/or elevators, benches or chairs, staffed ticket sales desks, commuter ticket sales desks, travel agency offices, free station-crossing passages, ATMs, bakery stores and/or confectioneries, supermarkets, bookstores and/or general goods shops, barbers or hair salons, massage shops, clinics, pharmacies, nurseries and/or kindergartens (on a one-to-three scale)
railway service	abundance of ticket vendors, little waiting time at ticket sales counters, station cleanliness, restroom cleanliness, wide platforms, platform screen doors, security, easy-to-understand departure guidance, many trains departures, express or faster trains are available, many originating trains (on a one-to-five scale)
presence of facilities around the station	retail shops, restaurants, commercial facilities, entertainment facilities (including movie theaters, game centers, bowling alleys, etc.), event facilities (including baseball stadium, soccer field, concert halls, etc.), tourism attractions (including shrines, temples, museums, zoo, amusement parks, etc.), administrative facilities (including governmental offices, courts, police stations, libraries, public halls, etc.), bus stops, taxi stands, bicycle parking lots, car parking lots, pickup or drop off points by car, roof on the station square (on a one-to-five scale)

Fig. 2 Relationship between responded and estimated attractiveness in Region A

Overall attractiveness of each station can be obtained by substituting the average evaluation for each element of each station obtained in the questionnaire for these regression equations.

The relationship between attractiveness and the element indicates that the attractiveness relates to the presence of shops,
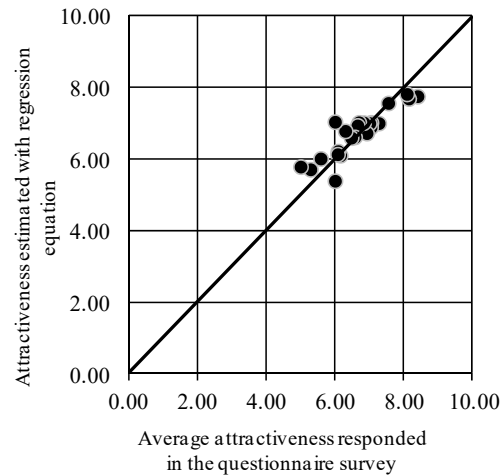

Fig. 3 Relationship between responded and estimated attractiveness in Region B

Correlation coefficients between the evaluated attractiveness obtained in the questionnaire and the attractiveness estimated with (1) and (2) for Regions A and B were 0.87 and 0.89, respectively, which indicates good estimation. Scatter plots shown in Figs. 2 and 3 also represent the good estimation performance of the developed equations.

III. Method of Estimating Passenger Volume Considering Attractiveness of Stations

In this section, we summarize the method and the verification result for calculating passenger volume based on the attractiveness obtained with the method explained in Section II and socioeconomic data such as the population around the station.

A. Developing the Method to Estimate Passenger Volume

Firstly, a regression analysis for Region A, elements such as attractiveness, residential and employment population, land use, the number of bus stops around the station being explanatory variables, and the average number of passengers per day at each station being the dependent variable. Since the number of passengers does not become a negative value, the constant term is set to 0. An example of the obtained regression equation is shown in (3):

Average number of passengers per day in the station =
2786 * attractiveness
+ 0.536 * residential population around the station
+ 1.778 * number of transit passengers
+ 3502 * number of bus stops around the station   (3)

Correlation coefficient between the actual and estimated passenger volume was 0.93. Fig. 4 also indicates the strong relationship. From these results, it was clearly indicated that the number of bus stops is also related to the number of passengers in the station, as well as the residential population around the station and number of passengers at the connecting station.

We redeveloped the above-mentioned equation by removing the attractiveness from the explanatory variables as shown in (4):

Average number of passengers per day in the station =
0.849 * residential population around the station
+ 2.388 * number of transit passengers
+ 4193 * number of bus stops around the station   (4)

The correlation coefficient for (4) was 0.89. This indicates that the inclusion of attractiveness into explanatory variables may result in has higher correlation coefficient and in estimating the number of passengers.

B. Verification of Passenger Volume Estimation Method in Another Region

As a case study, we applied the passenger estimation method for Region B as shown in (5):

Average number of passengers per day in the station =
6406 * attractiveness
+ 2.829 * number of employment around the station
+ 0.787 * number of transit passengers   (5)

The correlation coefficient between actual and estimated passenger volume was 0.96, which indicates a good estimation. Fig. 5 shows the relationship between actual and estimated passenger volume.

We again redeveloped (5) by removing attractiveness from the explanatory variables as shown in (6):

Average number of passengers per day in the station =
4.129 * number of employment around the station
+ 0.762 * number of transit passengers   (6)

The correlation coefficient in (6) was 0.95. As in the previous case, the correlation coefficient was higher when the attractiveness was included as an explanatory variable.
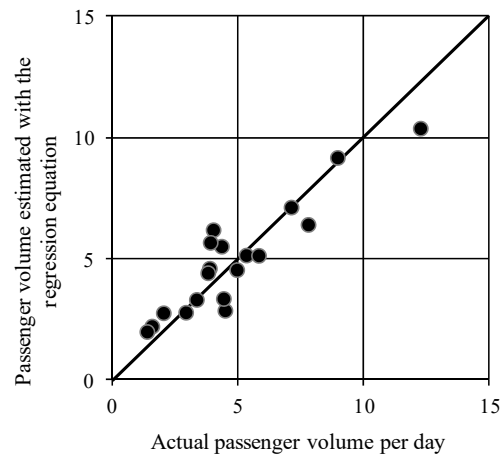

Fig. 4 Relationship between actual and estimated passenger volume in Region A
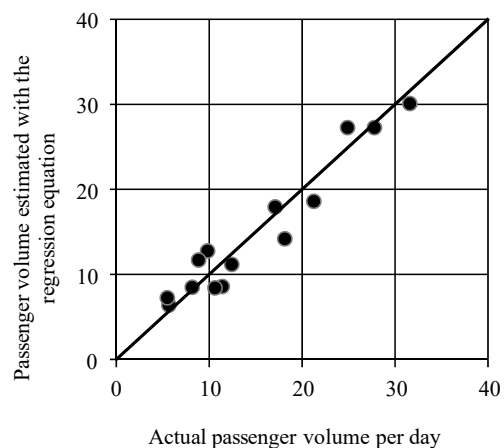

Fig. 5 Relationship between actual and estimated passenger volume in Region B

IV. Conclusion

We conducted a Web questionnaire survey on the attractiveness of the station and the degree of fulfillment of the facilities in and around the station, to those who live along the railway lines in metropolitan areas and frequently use the railway. As a result of the analysis, it was found that factors such as the cleanliness of the station, the large number of train departures, the degree of fulfillment of commercial facilities around the station, and the fulfillment of bus and taxi stands affect the attractiveness of the station.

We also developed a method to quantify the attractiveness

using the result of the questionnaire. Examples were obtained that the correlation coefficient between the attractiveness obtained in the questionnaire and the attractiveness estimated by this method was 0.87 to 0.89.

Analysis of the relationship between the data such as the residential population, employment, land use, the presence of transport facilities such as bus stations and car parking, the number of passengers at the connecting station, and the number of passengers at the station found that many of these affect the station attractiveness. We have developed a method to calculate passengers by combining these data and the attractiveness of the stations mentioned above, with regression analysis. Examples were obtained that the correlation coefficient between the actual and estimated daily passenger volume was 0.93 to 0.96.

As a future work, in order to improve the accuracy of estimation of the passenger volume using the stations, it may be considered to include the routes and frequency of buses through the station. Therefore, it may grasp the passenger volume of bus users more accurately.

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