Activity-end access/egress modal choices between stations and campuses located on a hillside

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ABSTRACT

This study investigates activity-end access/egress modal choices between railway stations and university campuses where topographical factors play an important role. Four campuses of Kobe University, Kobe, Japan are located close to three railway stations. The stations and campuses are 1.1–3.9 km apart, and the campuses are approximately 70–195 m higher in altitude than the stations. An online questionnaire survey was given to students to elicit their current modal choices and preferences for hypothetical direct bus services. An analysis compared the aggregate data and estimated the discrete choice models. The topographical factors of distance and altitude affected the mode choices when travelling uphill but not when travelling downhill. However, distance, not altitude, determined if walking was included in the choice set. One striking reason for occasional walking rather than taking a bus was to meet friends who walked to campuses. The reasons for using the same mode for the same direction differ when the respondents used different modes in the opposite direction. The value of time for uphill walkers is extremely small compared to that for uphill bus riders, suggesting that the direct bus services recently introduced by Kobe City's Bureau of Transport are attractive to current bus riders.

1. Introduction

First-mile transport and last-mile transport have received much attention these days (e.g. Nocera et al., 2020). Especially in the rail industry, the origins and destinations of passengers are not usually stations, and access to and egress from stations are always required. Compared to the percentage of distance travelled in access and egress during the entire journey, the percentage of time spent in the corresponding parts of the journey is much greater (Krygsman et al., 2004). When travel time multiplier—which converts time spent out-of-vehicle to equivalent time spent in-vehicle—is considered, the percentage of time spent in access and egress on an equivalent in-vehicle time basis is even larger. For the access and

egress legs, a typical travel time multiplier is two, meaning that one minute spent in access/egress is equivalent to two minutes spent inside a vehicle (Wardman et al., 2016).

Non-motorised transportation modes play a greater role in the access and egress legs due to their shorter distances. These modes are human powered and vulnerable to environmental factors, such as weather, topographical factors, and time of day. A focus of the present study is the topographical factors. Topographical factors are time-invariant, while other factors, such as weather and time of day, vary over time. The present study mainly focuses on the topographical factors that affect daily mode choices, but this study does mention other environmental factors that affect occasional modal changes.

Introducing notions of home-end and activity-end for a journey facilitates understanding of access and egress mode choices. Access and egress sometimes are confusing in the sense that the access leg of an outbound journey is identical to the mirrored egress leg of an inbound journey. Combining the ends of journey (home- or activity-end) and directions of journey (access or egress) produces home/access, home/egress, activity/access, and activity/egress. Most studies analysing terminal transport modal choices addressed only one of these four. The present study does not discuss the choices of home- and activity-end, which are determined by the scope of the analysis. On the other hand, the choice of either access or egress at the same end of a journey requires discussion. An assumption made in previous studies is that the same transportation mode is used for both access and egress at the same end. While this assumption is acceptable in most contexts, it is open to discussion in studies that analyse topographical factors.

The present study aims to analyse both access and egress transport mode choice at the activity-end of the journey. The analysis is focused on Kobe University (Kobe, Japan) and student access and egress mode choice at the activity-end (between their university campus and their nearest railway stations). Four campuses of Kobe University were chosen for the analysis. In Kobe, three railway lines run parallel to each other east to west. From north to south, these are the Hankyu line, the JR (Japan Railways) line, and the Hanshin line. Students that commute to/from the university by rail usually use one of three stations: Rokko on the Hankyu line, Rokkomichi on the JR line, and Mikage on the Hanshin line. This choice of study area has the following advantages for this study.

First, topographical factors play an important role on the modal choices in the first-mile and last-mile contexts in the study area. A notable geographic characteristic of the study area is the differences in altitude; the four campuses range between 130 m and 205 m in altitude, while the three stations range between 10 m and 60 m in altitude. Therefore, students must climb around 70–195 m to reach their campus. The distances between the stations and the campuses range between 1.1 km and 3.9 km. Therefore, the issues addressed in the present study are for typical first- and last-mile transportation.

Second, collecting the data required some effort. If the origin and destination of the access/egress leg at the activity-end are not fixed, then considerable effort is needed to prepare the topographical data for each leg. To reduce data processing requirements, the present study limits the access/egress leg to station-campus pairs. Of course, this approach limits variations in the data, but the station-campus pairs included in the present study mean

the analysis remains meaningful. Also, because the author is employed at Kobe University, data from students of that university was easy to collect.

Third and finally, students have various preferences in their mode choices. The transport modes chosen by students between the stations and campuses include walking, bus, taxi, and motorcycle. Walking is attractive for distances of less than one or two kilometres, but walking uphill for 20–30 minutes is not easy for all students. A good bus service is provided between the stations and campuses by the City of Kobe. These buses run at intervals of less than ten minutes during the morning peak hours and cost JPY 210. Another public transport option is to take a taxi. Although a taxi is more expensive than a bus, the cost is reasonable when students share the ride with friends. (Uber and other ride-sharing services are not allowed in Japan.) Motorcycles are more popular than bicycles due to the mountainous topology. In addition, some students change transportation mode in response to occasional environmental factors. Moreover, some students choose different transportation modes depending on whether they are going uphill or downhill. Analysing these issues also is of interest in this study.

This study investigates the following research questions (RQ1–RQ4) by comparing the aggregate shares and estimating disaggregate choice models. Although the topographical factor is the centre of the analysis, other factors are mentioned when necessary. In addition, the analyses in this paper provide the basis for comments on recent policies in Kobe to facilitate modal integration between the railways and buses for students. Note that the analyses do not treat each research question in the order shown here.[1] In the Conclusions Section (Section 8), the findings for each research question are summarised with reference to the analyses presented in the paper.

RQ1: How do modal shares differ among pairs of stations and campuses?
RQ2: What factors are important when students change their transport modes?
RQ3: Do students use the same transport modes in both directions?
RQ4: Do preferences vary among students?

The present study consisted of two parts: a questionnaire survey and an interview with the Kobe City's Bureau of Transport. The questionnaire survey was conducted in November 2017 and surveyed students' most, second-most, and third-most frequently used transportation modes from various stations to their campus and the reasons for changing modes. The transportation modes of travel from the four campuses to the three stations also are surveyed. The stated preference (SP) survey asked about the choices between bus and walking when a direct (non-stop) bus service is introduced between stations and campuses. Kobe City recently introduced a policy to facilitate modal integration between the railway and bus services by providing direct bus service from railway stations to schools. This paper

[1] Analyses corresponding to each research questions are summarised below.
RQ1: Table 6, Figure 6, and Models 1–4
RQ2: Figures 2 and 5, and Model 4
RQ3: Figures 3 and 4, Table 6, Figure 6, and Models 1–3
RQ4: Models 5–9

includes a summary of an interview with Kobe City's Bureau of Transport in which the policy is explained.

The remainder of this paper is organised as follows. Section 2 reviews related literature. Section 3 presents the four campuses of the Kobe University and the railway stations used by the university's students. Section 4 explains the online survey conducted in 2017. Section 5 presents the aggregate results and analyses of the survey. Section 6 estimates the mode choice models utilising revealed preference (RP) and stated preference data collected by the survey. Section 7 utilises models estimated in Section 6 to discuss implications for policy and practice of the modal integration being considered in Kobe. Section 8 provides the concluding remarks.

2 Literature review

This study aims to analyse both access and egress transport mode choices at the activity-end of the journey with emphasis on topographical factors. Existing studies considering topographical factors are reviewed by considering two dimensions: the end of journey (home- and activity-end) and the direction of journey (access and egress).

All of the following mode choice studies included the topographical factor of hilliness, such as the time difference with and without slope information, the altitude difference measured as maximum elevation minus minimum elevation, the intensity of up/down movement measured in degrees, the maximum slope measured in degrees, and the number of changing slopes. Studies of home-end terminal modal choices include Hayauchi et al. (2019) for egress in Yokohama, Japan, and Santoso et al. (2015) for access in Hidaka, Saitama, Japan. On the other hand, activity-end terminal modal choices have received less attention. (Some relevant studies are reviewed in the present study.) Rodríguez and Joo (2004) focused on mode choice for students and staff commuting to the University of North Carolina in Chapel Hill, U.S.A. Their study did not analyse terminal mode choice, but mode choice from home to campus. However, their study included the idea of activity-end, since all of the respondents commute to the same place of activity, i.e., university campus. Note that all three studies above assumed that the same transportation mode is used in both directions. Nguyen et al. (2017) had data to address this issue; they analysed all the shorter distance trips made in a residential district in Hiroshima, Japan. Their study area included stations, and the analysed trips might have included access to and egress from stations. However, they did not analyse terminal transportation mode choices.

Although none of the four studies above analysed both access and egress modal choices at the same end of the journey, topographical factors play an important role in some of the studies. The results are summarised here. Hayauchi et al. (2019) found that the disutility of walking uphill for 12 m with a 1 m altitude difference was equivalent to that of walking horizontally for 24 m. Santoso et al. (2015) found that neither gradient nor altitude difference had a statistically significant impact on both walking and bicycling at a five percent level of significance. Rodríguez and Joo (2004) found that the increased travel time caused by the slope had negatively statistically significant impacts on non-motorised modes. Nguyen et al. (2017) demonstrated that altitude difference had a statistically significantly positive impact on

motorised modes, meaning that altitude difference had a negative impact on non-motorised modes.

Other papers which did not include topographical factors but analysed both the access and egress modes of the journey are reviewed. Halldórsdóttir et al. (2017) estimated terminal mode choice models that included both home- and activity-end terminal mode choices. However, the study analysed only access to a railway station at the home-end and egress from a railway station at the activity-end, with an assumption that the same transportation mode is used in the same end of the journey. Su et al. (2009) analysed older people's modal choices before and after shopping to see if they used different transportation modes after shopping because they had something to carry. Although their dataset did not include enough respondents who changed their transportation mode, the present author shares their interest in this topic.

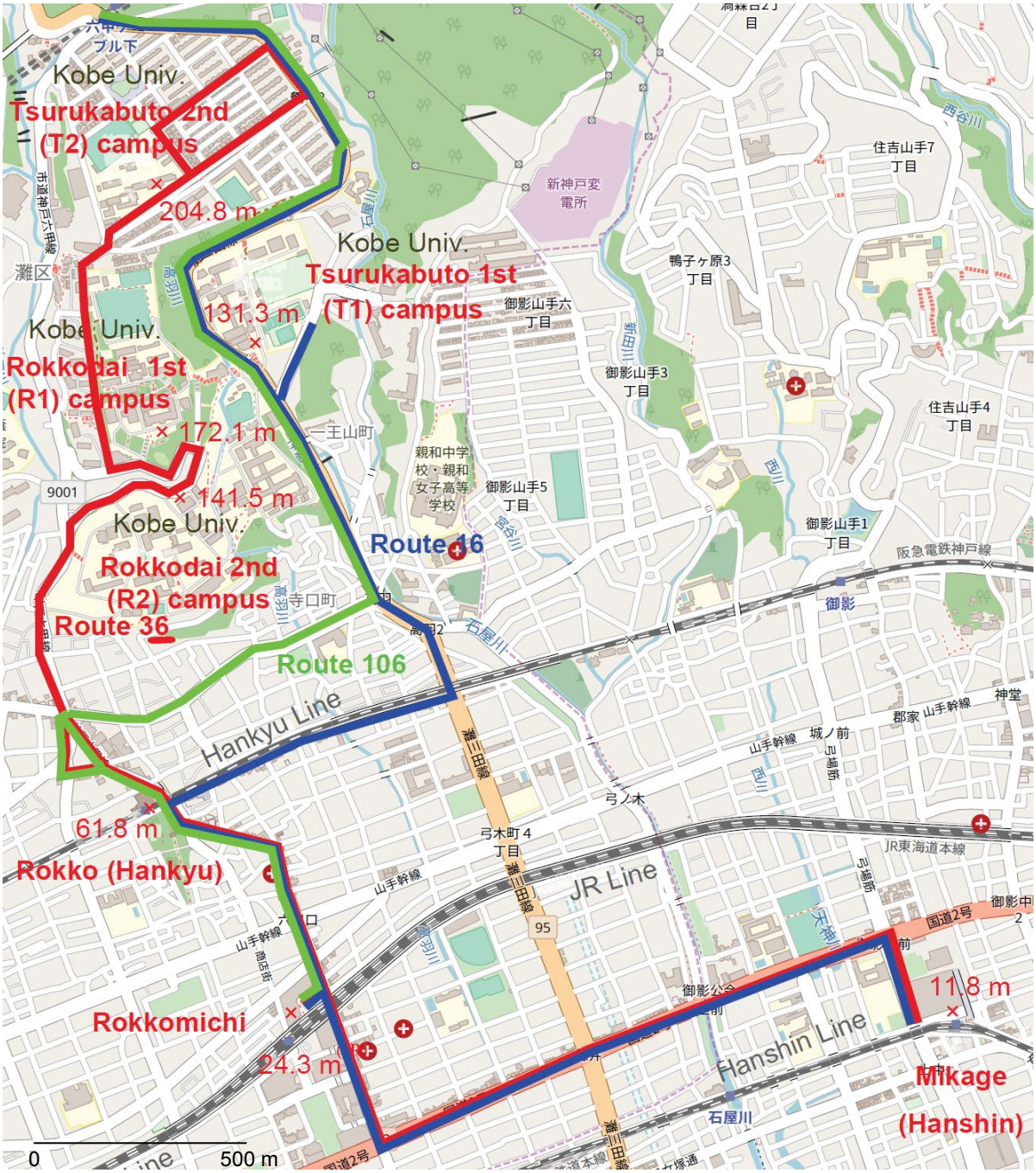
Meeder et al. (2017) is worth mentioning as they had an interest and target area similar to those of the present study. They chose station-campus transport in Zurich, Switzerland. There is an uphill slope from the station to the campus, and most commuters choose to either walk or take a tram. The number of walkers and tram riders were counted utilising infrared sensors mounted on a road section and the doorframes of tram vehicles, respectively. The results were difficult to interpret because the data could not identify the exact origins and destinations of the travellers. Meeder et al. estimated mode choice logit models that included parameters for slope variables. However, they did not adequately describe the data, such as which station-campus pairs and how many observations. Therefore, their data may not have had adequate variation in the slope variable. In addition, the parameter for the slope was estimated for uphill travel, but not for downhill travel (fixed to zero).

3 Campuses and stations

Established in 1902, Kobe University today has 10 faculties, 15 graduate schools, and a great number of research centres and institutions. The university has a staff of 3680 (including teaching and administrative) and 15,256 students (including undergraduate, graduate, and international) (Kobe University, 2018).

In April 2017, the newly enrolled undergraduate students came from prefectures near Kobe: Hyogo (23.3%), Osaka (25.3%), Kyoto (7.2%), and Nara (6.4%) (Kobe University, 2017). It is believed that most students lived with their parents and commuted to Kobe via public transportation. Commuting by car is not permitted without special permission.

Figure 1 depicts geographic characteristics of the Rokkodai 1st (R1), Rokkodai 2nd (R2), Tsurukabuto 1st (T1), and Tsurukabuto 2nd (T2) campuses of Kobe University and the surrounding public transportation networks. Three railway lines run parallel east to west. From north to south, these are Hankyu, JR, and Hanshin. The most frequently used stations by students on the three lines are Rokko (Hankyu), Rokkomichi (JR), and Mikage (Hanshin). All three lines are operated by private companies; JR is the former Japanese National Railways. The altitude of the four campuses and three stations is presented in Figure 1. The characteristics of the three railway stations are summarised in Table 1.



Note: The four campuses and three stations and their altitude are presented. Three bus routes are also presented.

Figure 1. Study area

Table 1. Characteristics of three railway stations

Station (Railway company)	From Osaka or Umeda		From Sannomiya		Frequency/day (both directions)	Notes
	Time (min)	Cost (JPY/month)[a]	Time (min)	Cost (JPY/month)[a]		
Rokko (Hankyu)	28	4230	7	2010	260	Network to Takarazuka and Kyoto
Rokkomichi (JR)	22	6780	3	2890	446	Former Japanese National Railways, nationwide network; shorter travel time
Mikage (Hanshin)	25	4390	6	3130	416	Through service to Himeji and Nara

[a] One-month pass (university students' discount rate) fare.

Osaka and Sannomiya stations are located in business and commercial areas. Students are less likely to live in these areas, but use the stations for transfer. Of course, the choices of railways by students depend on their residential locations, but their route choice is beyond the scope of the present study. More details on the study area and access/egress transport modes can be found in Sanko and Shoji (2009).

The four campuses of Kobe University are summarised in Table 2. Although different schools are located in different campuses, most of the undergraduate first- and second-year students study in the Tsurukabuto 1st campus irrespective of their schools or departments. Three bus routes connect the four campuses and the railway stations: bus routes 36, 16, and 106. Bus routes 36 and 16 run to the campuses from Mikage (Hanshin) with stops at Rokkomichi (JR) and Rokko (Hankyu). A limited number of buses run from Rokkomichi and Rokko. Some basic information about the service is provided in Table 3. The three routes also are depicted in Figure 1.

Table 2. Four campuses and bus routes

Campus	Schools	Bus Routes
Rokkodai 1st (R1)	Law; Economics; Business Administration; International Cooperation Studies	36
Rokkodai 2nd (R2)	Letters; Science; Agriculture; Engineering; System Informatics; Science, Technology and Innovation	36
Tsurukabuto 1st (T1)	Intercultural Studies; Global Human Sciences	16 and 106
Tsurukabuto 2nd (T2)	Human Development and Environment; Global Human Sciences	36

Source: Kobe University (2019)

Table 3. Bus routes connecting railway stations and campuses

Route	(only stations, campuses, and terminal stops are included)	Frequency (per weekday)
36	Mikage (Hanshin)—Rokkomichi (JR)—Rokko (Hankyu)—R2—R1—T2—Tsurukabuto Danchi	Uphill 63 (Mikage), 111 (Rokkomichi); Downhill 116 (R1), 65 (Rokkomichi)
16	Mikage (Hanshin)—Rokkomichi (JR)—Rokko (Hankyu)—T1—Rokko Cable Shita	Uphill 86 (Mikage), 142 (Rokkomichi); Downhill 146 (T1), 88 (Rokkomichi)
106	Rokkomichi (JR)—Rokko (Hankyu)—T1—Rokko Cable Shita	Uphill 7 (Rokkomichi); Downhill 7 (T1)

Note: R1, R2, T1, and T2 stand for Rokkodai 1st and 2nd, and Tsurukabuto 1st and 2nd, respectively.

Source: City of Kobe (2019)

4 Survey

The survey was designed to elicit the transportation modal choices of students between stations and their campus and the factors affecting those choices. An online survey was conducted utilising Google Forms between 6 and 14 November 2017. Respondents were limited to students of Kobe University. The survey was mainly distributed by the students named in the Acknowledgements and by their friends.

The survey consisted of three sections: (A) personal information, (B) commuting mode between stations and campuses, and (C) preferences for using direct (non-stop) bus between stations and campuses. Table 4 presents more details.

Table 4. Items surveyed

Section (A) Personal information
(1) gender
(2) school (faculty or department)
(3) use of rail when commuting to school
(4) station used when commuting to school [a]
(5) ownership of motorcycle, season pass for bus between stations and campuses [a]
(6) campus he/she most frequently commutes to from the station [a]
Section (B) Commuting mode between stations and campuses (Items (4) and (6) of Section (A)) [a]
(1) Most frequently used transport mode from stations to campuses
(2) Reasons of choosing the mode in (1)
(3) Second-most frequently used transport mode from stations to campuses
(4) Reasons for changing from the mode in (1) to the mode in (3)
(5) Third-most frequently used transport mode from stations to campuses
(6) Reasons for changing from the mode in (1) to the mode in (5)
(7) Most frequently used transport mode from campuses to stations
(8) Reasons for choosing the mode in (7)
Section (C) Stated preference survey
(1) Travel time on foot from the Hankyu Rokko Station to T1 campus restaurant
(2) Stated preference survey (8 choices per respondent)
Note that the travel time response in (1) is used as travel time on foot in (2).

[a] Asked for those who use rail in Item (3) of Section (A).

In Section (B), the questionnaire is designed to elicit not only the most frequently used transport mode but also their second- and third-most frequently used modes. Also asked are the transport mode when they travel from campuses to stations.

Section (C) asks respondents to choose either a non-stop bus or walking from Hankyu Rokko to the T1 campus restaurant. It might be ideal to customise the questions for each respondent and ask their mode choice for their most frequently used station-campus pair, but the present study used a simpler method. The Rokko (Hankyu)-T1 campus pair was adopted since it is believed to be the most frequently observed station-campus pair. Walking and non-stop bus alternatives were characterised by travel time and travel cost. Travel time and travel cost for the direct bus are designed by combining two levels of travel time—5 minutes (free flow) and 15 minutes (congested)—and four levels of bus fare—JPY 100, JPY 150, JPY 210, and JPY 250. (JPY 210 was chosen since it is the current level of service.) On the other hand, walking is free and the travel time for walking is the same as the travel time reported by respondents for Item (1) of Section (C). Travel time by walking varies from respondent to respondent, so the survey design was unrealistic.

5. Results

5.1 Descriptive statistics

287 observations were collected. Some descriptive statistics are presented in Table 5. Note that ‘campuses most frequently commute to’ and ‘most frequently used railway stations for commuting’ are asked to those who use railway for commuting. The following analysis focused on 12 station-campus pairs—the three stations of Rokkomichi, Rokko, and Mikage,

and the four campuses of Rokkodai 1st and 2nd and Tsurukabuto 1st and 2nd. Three of the 162 respondents who did not fall into the 12 pairs were removed from the analysis.

Table 5. Descriptive statistics

	n	%
Gender		
Male	148	51.57
Female	139	48.43
Grade		
Undergraduate 1st year	93	32.40
Undergraduate 2nd year	64	22.30
Undergraduate 3rd year	114	39.72
Undergraduate 4th year	15	5.23
Graduate 2nd year	1	0.35
School		
Business Administration; Economics; Law	154	53.66
Letters; Science; Agriculture	23	8.01
Engineering	29	10.10
Global Human Sciences; Intercultural Studies	39	13.59
Human Development and Environment	33	11.50
Maritime Sciences	4	1.39
Medicine	5	1.74
Railway use for commuting		
Yes	162	56.45
No	125	43.55
Campuses most frequently commute to*		
Rokkodai 1st (R1)	55	33.95
Rokkodai 2nd (R2)	24	14.81
Tsurukabuto 1st (T1)	62	38.27
Tsurukabuto 2nd (T2)	19	11.73
Others	2	1.23
Most frequently used railway stations for commuting*		
JR Rokkomichi	53	32.72
Hankyu Rokko	93	57.41
Hanshin Mikage	13	8.02
Others	3	1.85

* Those who answered ‘yes’ in railway use for commuting were requested to answer.

Regarding the representativeness of the sample, undergraduate students of the Business Administration, Economics, and Law schools, comprised 53.66% of the respondents. Respondents of the present study comprised approximately 10% of the undergraduate 1st and 3rd year students of the above three schools, while 2nd and 4th year students comprised a slightly lower percentage. The male-female ratio of students in the three schools was similar to statistics published by the university. The survey did not follow the procedure of random sampling, so generalisation might be an issue. However, the data still contains adequate information for the purpose of the present study, with some caution about generalisation.

5.2 Transportation modes

The most, second-most, and third-most frequently used transport modes from stations to campuses are presented in Figure 2. The same colour is used to represent the same transport mode. The centremost pie represents the most frequently used transport modes: 66, 1, 15, and 77 for walking, bicycle, motorcycle, and bus, respectively. The second pie from the centre represents the second-most frequently used transport modes. For example, the second-most frequently used transport modes for 66 walkers in the centremost pie were bicycle (1 respondent), bus (52), and car (1); 12 had no second transport mode. The

outermost pie represents the third-most frequently used transport modes. For example, the third-most frequently used transport modes for 52 respondents who choose walking and bus in their most and second-most frequently used modes, respectively, were taxi (4 respondents); 48 had no third transport mode.

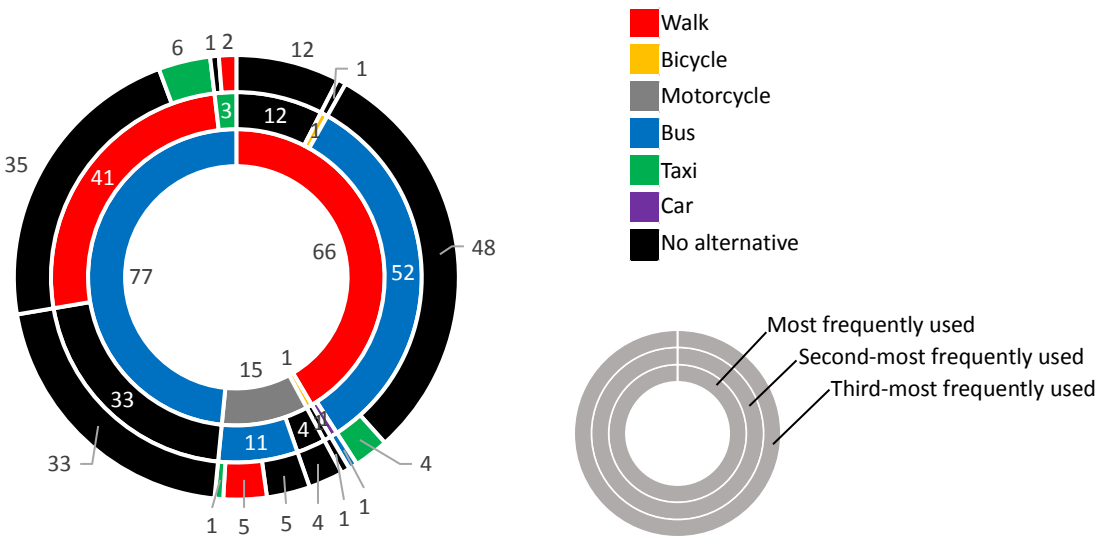


Figure 2. Most, second-most, and third-most frequently used transportation modes from stations to campuses

Figure 2 also indicates that walking and bus are the two major transportation modes answered by students as their most and second-most frequently used modes. The number of respondents for the most and second-most frequently used modes is 66 and 41, respectively for walking and 77 and 63, respectively for bus. Those whose first choice was walking tended to choose bus as their second choice, while those whose first choice was bus tended to choose walking as their second choice. Some chose taxi as their third mode, which is used when they wish to avoid a late arrival. Sometimes students shared a taxi with their friends, and the cost differed little from that of the bus.

Figure 3 compares transportation modes by directions, i.e., to campuses and to stations. The inner pie represents the most frequently used transport modes from stations to campuses (which is identical to the centremost pie in Figure 2), while the outer pie represents transport modes from campuses to stations. Similar to Figure 2, the modes chosen in the inner pie are broken down in the outer pie, and the same colour represents the same transportation mode. Those who walked or rode motorcycles to campuses used the same transportation modes when they went back to the stations. However, 77 users of buses to commute to campuses had mixed mode choices to stations—35 used bus and 42 walked.

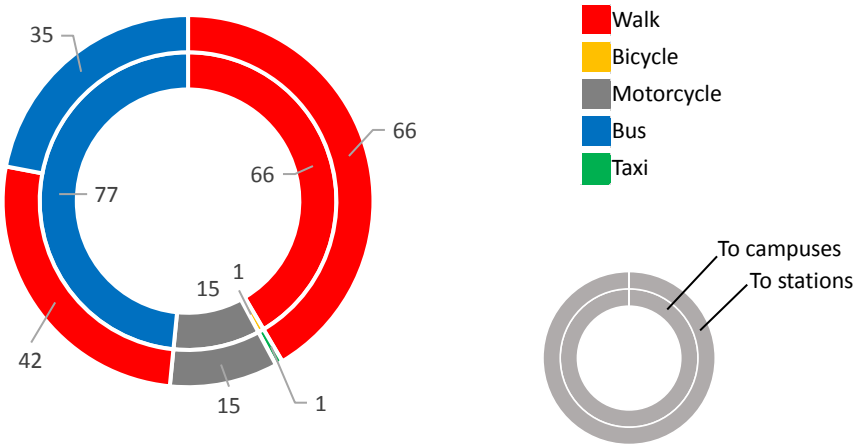
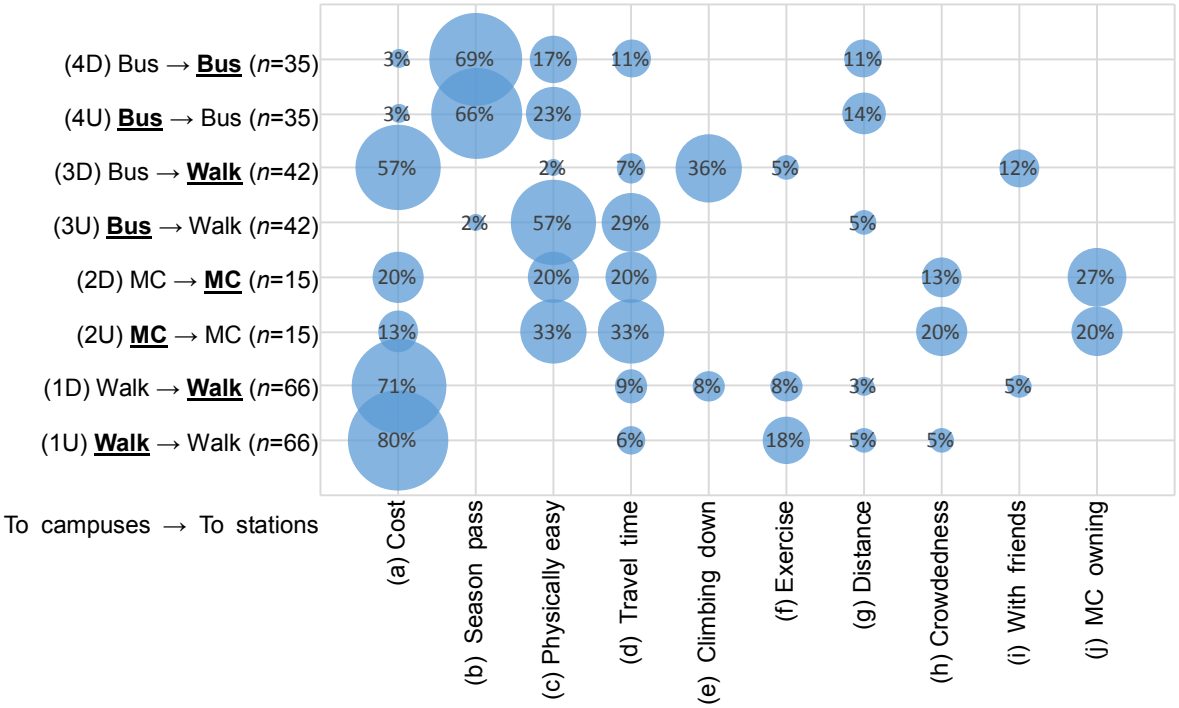


Figure 3. Transportation modes by directions



Note: Some gave more than one reason, and so the sum of percentages is not equal to 100%. Reasons not in (a)–(j) are omitted. Bubble sizes (areas) are proportional to percentages. MC stands for motorcycle. The (1)–(4) notations refer to the four combinations of modes to campuses and stations, and the 'U' and 'D' notations refer to 'Uphill (to campuses)' and 'Downhill (to stations)', respectively.

Figure 4. Reasons for choosing the most frequently used modes by directions

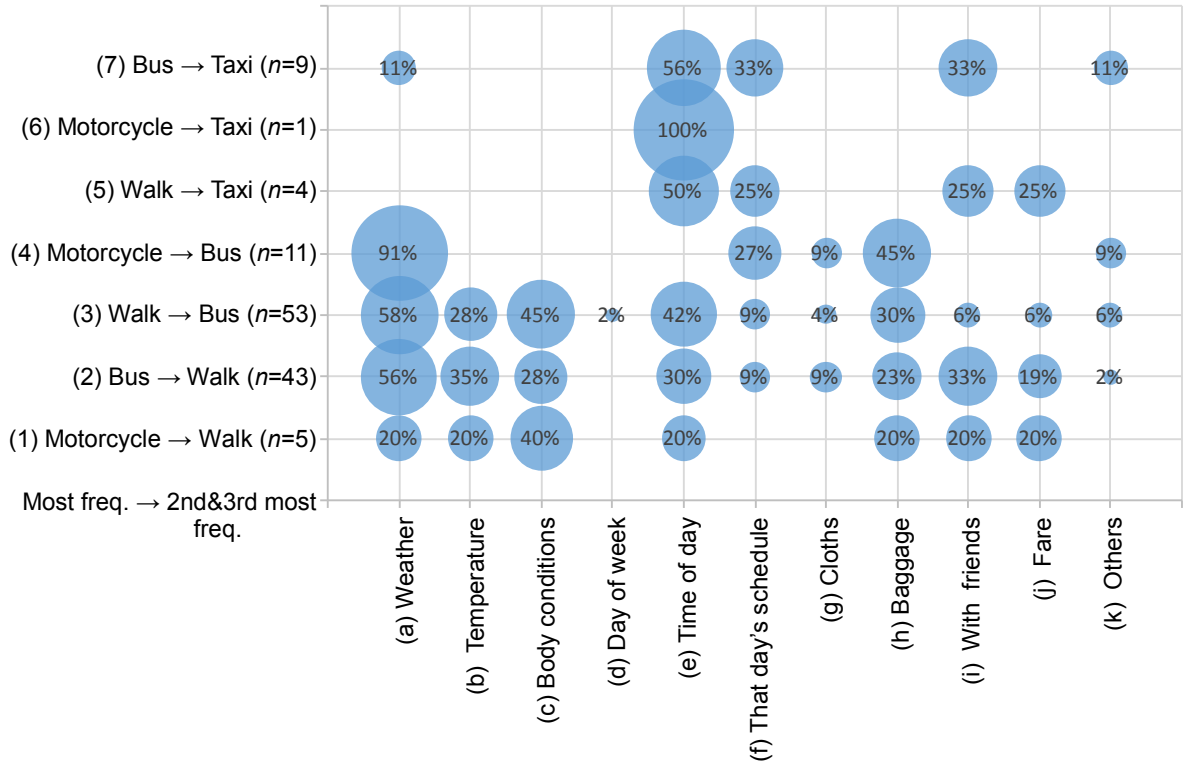
Figure 4 summarises the reasons for choosing the most frequently used transport modes when they travelled to campuses and to stations. Different transport modes were chosen for different reasons; Figure 4 deepens the analysis further. For example, the reasons for travelling to campuses by bus might differ among those who also travelled to stations by bus and those who walked to stations. Therefore, the respondents are grouped into the four most frequently observed combinations relating to modes chosen in both directions—(1) walking (to campuses) and walking (to stations); (2) motorcycle and motorcycle; (3) bus and walking; and (4) bus and bus. For each of the four combinations, the reasons for choosing the modes

for each direction are summarised. The 'U' and 'D' notations in Figure 4 represent 'Uphill (to campuses)' and 'Downhill (to stations)', respectively. The reasons were given in open-ended format, so coding was done by the present author. Some respondents gave more than one reason, and so the sum of the percentages is not equal to 100%. Reasons not categorised in (a)–(j) are omitted for brevity.

Those who used the same transport mode in both directions expressed similar reasons for choosing that mode for both directions.[2] For those who walked in both directions (see (1U) and (1D)), (a) cost (JPY 0) was the most frequently given reason. Other reasons were: (d) walking is faster (higher percentage for going down); (f) good exercise (higher percentage in climbing up); (g) not far for walking; (h) do not like crowded buses (to campuses in the morning); (e) easy for going down; (i) walking down with friends. For those who rode a motorcycle in both directions (see (2U) and (2D)), reasons given included: (a) cheaper than bus; (c) physically easy; (d) faster mode; (h) do not like crowded buses (higher percentages to campuses in the morning); (j) own motorcycle. For those who used a bus in both directions (see (4U) and (4D)), (b) owning a season pass was the most frequently given reason. Other reasons were: (c) physically easy; (g) far for walking; (a) JPY 210 is cheap; (d) faster mode (only for going down). Reasons for those who use different transportation modes (bus to campuses and walk to stations) are worth investigation. Reasons of using bus to campuses differ between (3U) and (4U). The two most frequently given reasons were (b) season pass and (c) physically easy in (4U) and (c) physically easy and (d) travel time in (3U). Reasons for walking to stations differ between (1D) and (3D). In (3D), (a) cost is less frequently given as a reason; (e) going down and (i) with friends were more frequently given as reason.

Figure 5 presents the reasons for changing from their most frequently used modes to their second- and third-most frequently used modes when they travelled to campuses. Figure 2 shows that the top three most frequently used modes are walking, bus, and motorcycle, while the top three second- and third-most frequently used modes are walking, bus, and taxi. Therefore, combinations of these modes were examined. In Figure 5, (1)–(7) are sorted by the second- and third-most frequently used modes. Note that the second- and third-most frequently used modes are combined in the analysis. For example, the numbers of respondents who answered walking in their most frequently used mode and changed to bus as their second- and third-most frequently used modes were 52 and 1, respectively. In '(3) Walk→ Bus (n=53)', these 52 and 1 observations are combined. Respondents were requested to choose up to three reasons from the list of reasons in the questionnaire, and so the sum of percentages is not equal to 100%.

[2] The reasons were answered in open-ended, and this paragraph uses original expressions provided by respondents in interpretation. The reasons mentioned in this paragraph do not exactly correspond to the (a)–(j) categories used in Figure 4. Therefore, this paragraph states the reasons with (a)–(j) notations in order to facilitate reader understanding.



Note: Respondents were requested to choose up to three reasons, and so the sum of percentages is not equal to 100%. Bubble sizes (areas) are proportional to percentages.

Figure 5. Reasons of changing transportation modes from station to campus

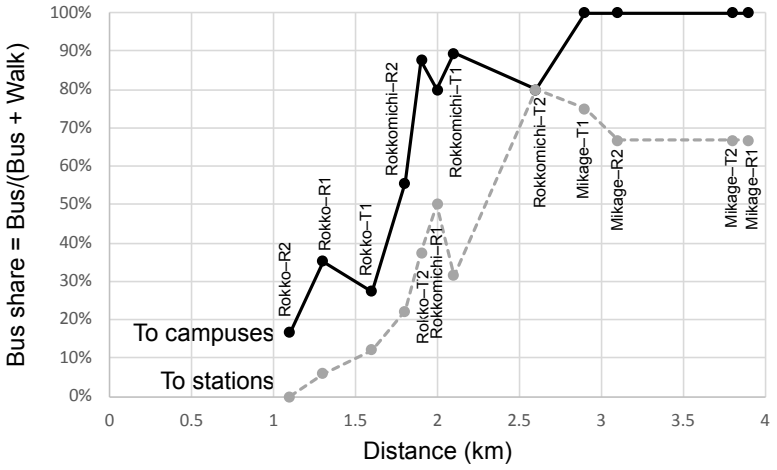
Those who changed to walking in (1) and (2) gave as reasons the weather, temperature, body conditions, time of day, baggage, with friends, and fare. Those who changed to bus in (3) and (4) gave as reasons the weather and baggage. Temperature, body conditions, and time of day were chosen only by those who changed from walking, and that day's schedule was more frequently chosen by those who changed from motorcycle. For those who changed to taxi in (5)–(7), time of day and with friends are frequently given as reasons. Taxi was used when they arrived late or when they met their friends to share a taxi. Taking the number of observations into account, '(i) With friends' is an especially important reason when students changed from bus to walking.

In the study area, distance and altitude difference are two striking aspects in determining geographical characteristics. Mode choice and geographical characteristics by directions and station-campus pairs are presented in Table 6 and Figure 6. In two panels of Figure 6, the vertical axis represents bus modal share (bus in percentage of bus and walk). The horizontal axes in panels (a) and (b), respectively, represent distance and altitude difference for each station-campus pair. Distance is measured using Google Maps for walking, since the distance is more important for walking than for riding the bus. Altitude is measured using data from the Geospatial Information Authority of Japan (2019). Altitude difference is defined as the altitude at the campuses minus the altitude at the stations. In the station-campus pairs, the slope is roughly constant for walking, so the campus and station roughly correspond to the highest and lowest points in altitude. Generally speaking, the farther the distance between stations and campuses, the larger the percentage of bus shares. The

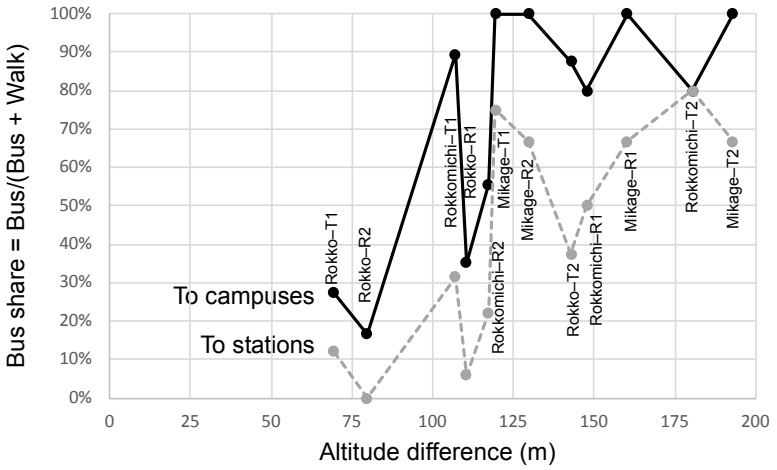
larger the altitude differences between stations and campuses, the larger the percentage of bus shares. While altitude difference and distance had positive correlations in the study area, distance was a more determinant factor on modal shares. Figure 6 indicates that, in all station-campus pairs, bus share is lower for stations than for campuses by about 10–20 percentage points.

Table 6. Mode choice and geographical characteristics by direction and station-campus pair

Station	Campus	Distance (km) when walking	Altitude difference (m)	To campuses (n)		To stations (n)	
				Walk	Bus	Walk	Bus
Rokko (Hankyu)	R1	1.3	110.3	22	12	32	2
Rokko (Hankyu)	R2	1.1	79.7	10	2	12	0
Rokko (Hankyu)	T1	1.6	69.5	24	9	29	4
Rokko (Hankyu)	T2	1.9	143.0	1	7	5	3
Rokkomichi (JR)	R1	2.0	147.8	2	8	5	5
Rokkomichi (JR)	R2	1.8	117.2	4	5	7	2
Rokkomichi (JR)	T1	2.1	107.0	2	17	13	6
Rokkomichi (JR)	T2	2.6	180.5	1	4	1	4
Mikage (Hanshin)	R1	3.9	160.3	0	3	1	2
Mikage (Hanshin)	R2	3.1	129.7	0	3	1	2
Mikage (Hanshin)	T1	2.9	119.5	0	4	1	3
Mikage (Hanshin)	T2	3.8	193.0	0	3	1	2



(a) Distance and modal share



(b) Altitude difference and modal share

Figure 6. Modal share and geographical characteristics by direction and station-campus pair

6 Access and egress mode choice models

This section presents mode choice models by utilising both revealed preference (RP) data and stated preference (SP) data.

6.1 RP model

The RP data consists of the responses to Section (B), Items (1), (3), (5), and (7) in Table 4. The following four models are estimated.

- Model 1 (Uphill model): The most frequently used mode to campuses (uphill) (Table 4, Section (B), Item (1)).
- Model 2 (Downhill model): The most frequently used mode to stations (downhill) (Table 4, Section (B), Item (7)).
- Model 3 (Uphill and downhill joint model): Combinations of the most frequently used modes to campuses (uphill) and to stations (downhill) (Table 4, Section (B), Items (1) and (7)).
- Model 4 (Uphill most frequently used and alternative modes joint model): Combinations of the most frequently and alternative transportation modes to campuses (uphill) (Table 4, Section (B), Items (1), (3), and (5)).

The transportation modes considered in the above four models are limited to walking and bus, since these modes are the two most frequently used modes. In addition, holders of season bus passes are excluded since they are considered to be captive.

For models 1 and 2, binary logit models are estimated, where the alternatives are walking and bus. For model 3, a multinomial logit model is estimated, where the alternatives are walking (uphill and downhill), bus (uphill) and walking (downhill), and bus (uphill and downhill). For model 4, a multinomial logit model is estimated. The most frequently used modes correspond to Section (B), Item (1), in Table 4, while alternative modes are generated by combining responses to Section (B), Items (3) and (5), in Table 4. Specifically, for those who answered that walking was their most frequently used mode, if the second or third most frequently used modes included bus, their alternative mode was bus; otherwise none (including a case where the second and third most frequently used modes included only modes other than buses). For those who answered that taking the bus was their most frequently used mode, alternative transportation modes of walking and none are defined similarly. Therefore, the alternatives for model 4 are walking (most frequent) and none (alternative), walking and bus, bus and walking, and bus and none.

The explanatory variables are the constant, the distance, and the altitude difference. As mentioned in Section 5.2, distance is measured along the walking route, and altitude difference is measured by subtracting the altitude at the station from the altitude at the campus. Travel cost and travel time are two typical variables included in mode choice models; these are not included here. Travel cost is free for walking and JPY 210 (flat fare) for the bus; they cannot be distinguished from the alternative-specific constant. Although the travel time for walking is not requested for the RP context, this can be addressed in two possible ways. The first option is to calculate the walking time based on the distance and altitude difference for each station-campus pair. However, this assumes identical travel times

for all students travelling the same station-campus pair, which is unreasonable since the students' physical abilities vary considerably. The second option is to convert the walking time response for travel from Hankyu Rokko to T1 campus in Table 4, Section (C), Item (1), taking into consideration the distance and altitude difference. The first option is not a good idea since the separately identified distance and altitude difference are converted to the single variable of travel time, which results in the loss of information. Also, both options need a conversion rule that requires a strong assumption to be made. Most studies utilised only a single variable, either travel distance or time (e.g., Young and Blainey, 2018). van Soest et al. (2020) reviewed studies on public transport-related walking (distance or time) and expressed a concern that travel distance and time are incorrectly measured in a lot of studies. In the present study, where both ends of access/egress legs are fixed, the distance and altitude difference were more accurate, and so travel time is not included in the analysis.[3] Explanatory variables are included in the walking alternative in models 1 and 2, where bus is the base as well as in the first two alternatives in model 3, where bus (uphill and downhill) is the base, and in the first three alternatives in model 4, where alternative of bus (most frequently) and none (alternative) is the base.

The results are presented in Table 7. In model 1, the distance and the altitude difference had significant negative effects with at least a 10% level of significance, while both were insignificant in model 2. This is consistent with Broach (2016), who found that the upslope had an impact on pedestrians' route choice while the downslope did not. Model 3 suggested that statistically significant estimates are obtained for walking (up & down), but were not significant for taking the bus (up) and walking (down), where the estimates were still negative. Those who chose walking alternative in Model 1 are identical to those who chose walking (up & down) alternative in model 3, so this is understandable. In model 4, only distance was statistically significant, suggesting that the walking alternative is highly related to distance. Distance must be in a certain limit for walking to be included in the choice set. The distance had a larger impact on the absolute value for walking (most frequent) and none (alternative) followed by walking (most frequent) and bus (alternative) and bus (most frequent) and walking (alternative), which is also reasonable.

[3] The present author included travel time (walking time calculated by the second option and bus time calculated from timetable) instead of distance and altitude difference for models 1 and 2, but this resulted in poor estimates.

Table 7. Estimates for RP choice model (*t*-stat. in parentheses)

	Alternatives	Constant	Distance (km)	Alt. diff. (100 m)	N	Final log-likelihood	Adj. rho-sq.
Model 1. Uphill	Walk	5.506	-1.976	-1.817	111	-60.751	0.171
		(4.53)	(-2.91)	(-1.89)			
	Bus (base)	--	--	--			
Model 2. Downhill	Walk	8.485	-0.889	-3.176	111	-16.130	0.751
		(4.13)	(-1.02)	(-1.50)			
	Bus (base)	--	--	--			
Model 3. Uphill & downhill joint	Walk (up & down)	11.734	-2.519	-4.156	111	-74.793	0.337
		(4.83)	(-2.36)	(-1.88)			
	Bus (up) & walk (down)	6.438	-0.608	-2.511			
		(3.01)	(-0.70)	(-1.20)			
	Bus (up & down) (base)	--	--	--			
Model 4. Uphill most freq. & alt. joint	Walk (most freq.) & none (alt.)	9.989	-5.020	-1.489	111	-114.138	0.200
		(3.56)	(-3.07)	(-0.75)			
	Walk (most freq.) & bus (alt.)	9.461	-4.534	-0.158			
		(4.50)	(-3.47)	(-0.10)			
	Bus (most freq.) & walk (alt.)	5.203	-3.491	1.785			
		(2.61)	(-2.75)	(1.18)			
	Bus (most freq.) and none (alt.) (base)	--	--	--			

6.2 SP model

SP surveys are conducted in a context of mode choice from Hankyu Rokko station to the restaurant at the Tsurukabuto 1st (T1) campus. The respondents were requested to choose between taking a non-stop bus, the cost and travel time of which are designed in the survey, and walking, the cost of which is JPY 0 and the time for which is as reported by the respondent.

Binary logit mode choice models were estimated and are presented in Table 8. First, 888 observations, i.e., eight observations from each of 111 students, are utilised to estimate the model in Model 5. Then, models are estimated for each segment defined by RP choice in Models 6–9. The idea of segmentation comes from Models 1–4 for Models 6–9.

Activity-end access/egress modal choices between stations and campuses located on a hillside

Table 8. Estimates for SP choice model considering segmentation (*t*-stat. in parentheses)

	Constant (Walk)	Time (hr)	Cost (JPY 1000)	N	Final log-likelihood	Adj. rho-sq.	VoT (JPY/hr)	Likelihood ratio test
Model 5. All	-0.669	-1.812	-9.684	888	-533.770	0.128	187.06	--
	(-2.68)	(-3.22)	(-7.34)					
Model 6a. Walk (up)	-1.120	-1.975	-21.289	528	-179.115	0.502	92.76	267.756
	(-2.48)	(-2.12)	(-7.07)					
Model 6b. Bus (up)	-1.612	-3.427	-9.241	360	-220.776	0.103	370.89	
	(-3.93)	(-3.82)	(-4.48)					
Model 7a. Walk (down)	-0.592	-2.017	-10.156	840	-488.303	0.156	198.61	41.120
	(-2.27)	(-3.37)	(-7.29)					
Model 7b. Bus (down)	-2.897	-2.053	-11.219	48	-24.906	0.161	182.99	
	(-2.18)	(-0.99)	(-1.71)					
Model 8a. Walk (up), walk (down)	-1.120	-1.975	-21.289	528	-179.115	0.502	92.76	274.029
	(-2.48)	(-2.12)	(-7.07)					
Model 8b. Bus (up), walk (down)	-1.413	-3.985	-9.197	312	-192.734	0.095	433.36	
	(-3.23)	(-3.89)	(-4.17)					
Model 8c. Bus (up), bus (down)	-2.897	-2.053	-11.219	48	-24.906	0.161	182.99	
	(-2.18)	(-0.99)	(-1.71)					
Model 9a. Walk (most freq.) & none (alt.)	-14.616	-20.119	-220.907	104	-3.497	0.910	91.08	299.771
	(-0.03)	(-0.82)	(-0.05)					
Model 9b. Walk (most freq.) & bus (alt.)	-1.584	-1.477	-21.950	424	-160.252	0.445	67.30	
	(-3.35)	(-1.56)	(-7.08)					
Model 9c. Bus (most freq.) & walk (alt.)	-1.468	-4.159	-9.242	224	-137.073	0.098	450.05	
	(-2.86)	(-3.53)	(-3.53)					
Model 9d. Bus (most freq.) & none (alt.)	-1.903	-2.218	-9.337	136	-83.063	0.087	237.60	
	(-2.76)	(-1.56)	(-2.76)					

Note: Constant is specific to walking. Time and cost are generic, but note that travel cost is always zero for walking. Likelihood ratio tests examined parameter equalities across segments.

For model 5, both travel time and cost were estimated negatively with statistical significance. The value of time was 187.06 JPY/hr. In model 6, mode choice uphill is utilised for segmentation. Although both travel time and cost were estimated negatively with statistical significance, there is a notable difference between the values of travel time, with a larger value of time for bus users traveling uphill, which is reasonable. In model 7, mode choice downhill is utilised for segmentation. Model 7b had insignificant estimates, likely due to the smaller number of observations. Model 7 is less reliable, since the likelihood ratio test indicated that the improvement in model fit is small compared to that for the other models. In model 8, various combinations of mode choice in uphill and downhill are utilised for segmentation. Note that models 6a and 8a are identical, as are models 7b and 8c. Again, taking the bus uphill and walking downhill had a large value of time. In model 9, combinations of the most frequently used mode and alternative transportation modes uphill are utilised for segmentation. Those whose most frequently used modes are walking have smaller values of time. This suggests that regular walkers and regular bus users have different values of time.

7 Implications for policy and practice

The Bureau of Transport for Kobe City began addressing the issues of modal integration for students for their first- and last-mile transport. This section presents some recent policies introduced by Kobe City. The contents in this section are mainly based on an interview conducted by the author with the city's Bureau of Transport on 28 June 2019.

The Bureau of Transport has suffered a great decline in patronage over the years, so the bureau has begun providing a form of student-only service. Since the bureau does not have

a chartered-bus licence, the direct service is operated under a fixed-route licence. Passengers other than students can use the service, so the bus is not students-only. However, this is a form of students-only service, since it is very convenient for students but not so much for other passengers. Some conflicts have been reported between students and other passengers, e.g. talking loudly, carrying large bags, and so on. This service also aims to solve those problems.

The City of Kobe has published a regional public transport network formation plan, which states that railways provide service on trunk routes, and buses and other modes take the role of feeders to and from stations. A policy of modal integration matches the concept of the plan.

Table 9 presents the direct services that are available between the stations and the Kobe University campuses. A direct (non-stop) bus service was introduced in April 2017. Two direct services run on school day mornings from Rokkomich Station to Tsurukabuto 1st campus. In the following year, the number of services from Rokkomichi increased to three services (one regular and two extra in case of high demand), and a new service from Rokko was introduced. In addition, a new bus stop was constructed inside the gate of the campus. Services on Fridays, however, were abolished due to low demand. The buses are always full to capacity, with demand fluctuating with late train arrivals.

Table 9. Direct service between stations and Kobe University campuses

Route	From	To	Starts from mm/yy	Notes
16	Rokkomichi Sta.	T1 campus	04/17	Two services on school day mornings (no station-bound service)
16	Rokkomichi Sta.	T1 campus (inside gate)	04/18	Three services (one regular and two extra in case of high demand) on school day mornings except Fridays (no station-bound service)
16	Rokko Sta.	T1 campus (inside gate)	04/18	Two services (one regular and one extra in case of high demand) on school day mornings except Fridays (no station-bound service)

The City of Kobe has introduced other direct services to schools (not presented in this paper). Most operate only on school day mornings, and station-bound service is provided on some routes. One route differs slightly from the others. Some schools are located on certain bus stops on the route. Therefore, two services on school day mornings stop only at railway stations and certain bus stops near the schools.

According to results from SP models, the author concludes that the direct service is attractive for regular bus users (uphill) but not for regular walkers very much. The value of travel time for bus users (uphill) is 370 JPY/hr in model 6b, while that for walkers (uphill) is 92 JPY/hr. The bus users already pay JPY 210, so an additional travel time reduction of two minutes has a value of 370*2/60 = JPY 12.3.[4] This means that a fare increase of JPY 12.3 might be accepted if it enabled them to save two minutes. Skipping intermediate bus stops likely

[4] Model 6b was estimated after excluding respondents who reported extremely shorter walking time. The value of time was 654 JPY/hr, and travel time reduction of two minutes has a value of 654*2/60 = JPY 21.8.

results in a two-minute reduction in travel time, so the policy is reasonable. However, those who walk need a 210/92 = 2.28 hr reduction in time to justify paying JPY 210 (the current fare). The author concludes that a reduction in travel time is inadequate for them to justify taking the bus.

8 Conclusions

This paper conducted a unique study analysing both the access and egress mode choices of activity-end of university students commuting trips between university campuses and the nearest stations. A focus of the study was the impact of topographical factors on modal choices, so the study area was selected based on assumptions that the transportation modes might differ by direction of the journey and that transportation modes might differ even in the same directions of the journey for various reasons.

Four campuses of Kobe University (Kobe, Japan) and the three nearest railway stations operated by three private railway companies were chosen for the analysis. The distances between the stations and the campuses range from 1.1 to 3.9 km, and the differences in altitude between the stations and the campuses range from 70 to 195 m. Therefore, the topic of this paper is a typical first- and last-mile transportation problem. The analysis was conducted in two ways: an online questionnaire survey and an interview with the Bureau of Transport for Kobe City.

Findings relating to research questions presented in Section 1 are summarised below.

- RQ1: How do modal shares differ among pairs of stations and campuses?
  As shown in Table 6 and Figure 6, the modal shares differ significantly among different pairs of stations and campuses. Generally speaking, the farther the distance between the stations and the campuses, the larger the percentage of bus riders. The larger the altitude differences between stations and campuses, the larger the percentage of bus riders. While altitude difference and distance had positive correlations in the study area, distance was a more determinant factor on modal shares. In Models 1–4, topographical factors of distance and altitude difference have impacts on mode choices.
- RQ2: What factors are important when students change their transport modes?
  As shown in Figure 2, those whose first choice was walking tended to choose taking the bus as their second choice, while those whose first choice was taking the bus tended to choose walking as their second choice. Some chose taxi as their third mode. Figure 5 summarises the reasons for changing modes; one of striking reason for changing from taking a bus to walking is to meet friends who walk. Model 4 analysed various combinations of the most frequently used and alternative transportation modes uphill and found that distance, not altitude difference, had a statistically significant impact, so there is a certain limit on distance beyond which walking is not included in the choice set. This is irrespective of the most frequently used mode or alternative mode.
- RQ3: Do students use the same transport modes in both directions?
  As shown in Figure 3, more than half of those who ride buses to their campus walk to the stations. Figure 4 summarises the reasons for mode choices in each direction. The reasons for using the same mode in the same direction differ if the respondents

use different modes in the opposite direction. For example, the reasons for taking the bus uphill differs between those who also take the bus downhill and those who walk downhill. Table 6 and Figure 6 showed that the percentage of those who walk downhill is about 20 percentage points larger than that of those who walk uphill. Models 1–3 suggest that distance and altitude differences had statistically significant impacts on uphill walking decisions.

- RQ4: Do preference among students vary?
  Models 5–9 demonstrated that the value of time for uphill walkers is extremely small compared to that for uphill bus riders. This is utilised to make comments on the direct bus services introduced by the Kobe City's Bureau of Transport. Direct bus services are only available on school day mornings for school-bound students. Bus stops are sometimes constructed inside the gates of campuses, which is more convenient for students. According to the value of travel time found in Models 5–9, the service is attractive for current bus users, who already pay JPY 210 and might pay extra for a reduction in travel time (for example, an additional JPY 12.3 for a two-minute reduction). Although the present study found differences in preferences, the factors behind the different preferences were not investigated. Investigating these factors is a topic for future study, which could consider individual socio-economic characteristics and habitual behaviours.

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Declaration of interest

Declarations of interest: none.

References

Broach, J. P. (2016). Travel mode choice framework incorporating realistic bike and walk routes. Ph. D. dissertation, Portland State University. DOI: 10.15760/etd.2698

City of Kobe (2019). http://www.city.kobe.lg.jp/life/access/transport/bus/keito.html (accessed on 19 June 2019)

Geospatial Information Authority of Japan. (2019). https://maps.gsi.go.jp/ (accessed on 3 July 2019)

Halldórsdóttir, K. Nielsen, O. A., Prato, C. G. (2017). Home-end and activity-end preferences for access to and egress from train stations in the Copenhagen region. *International Journal of Sustainable Transportation*, 11 (10), 776–786, DOI: 10.1080/15568318.2017.1317888

Hayauchi, G., Nakamura, F., Ariyoshi, R., Tanaka, S., Miura, S. (2019). A study on influence of topographical factors to mode choice. *Journal of Japan Society of Civil Engineers, Ser. D3 (Infrastructure Planning and Management)*, 75(5), I_565–I_574, DOI: 10.2208/jscejipm.75.I_565

Kobe University (2017). *Statistics of Kobe University FY 2017* http://www.kobe-u.ac.jp/documents/info/outline/datashiryoushuu/2017/datashiryoushuu_2017.pdf (accessed on 18 June 2019)

Kobe University (2018). *Kobe University 2018–2019* http://www.office.kobe-u.ac.jp/ipiep/materials/brochure_KU2018-19.pdf (accessed on 18 June 2019)

Kobe University (2019). http://www.kobe-u.ac.jp/guid/access/index.html (accessed on 18 June 2019)

Krygsman, S., Dijst, M., Arentze, T. (2004). Multimodal public transport: an analysis of travel time elements and the interconnectivity ratio. *Transport Policy*, 11 (3), 265–275, DOI: 10.1016/j.tranpol.2003.12.001

Meeder, M., Aebi, T., Weidmann, U. (2017). The influence of slope on walking activity and the pedestrian modal share. *Transportation Research Procedia*, 27, 141–147, DOI: 10.1016/j.trpro.2017.12.095

Nguyen, T. A. H., Chikaraishi, M., Seya, H., Fujiwara, A., Zhang, J. (2017). Elderly's heterogeneous responses to topographical factors in travel mode choice within a hilly neighborhood: an analysis based on combined GPS and paper-based surveys. *European Journal of Transport and Infrastructure Research*, 17 (3), 411–424, DOI: 10.18757/ejtir.2017.17.3.3204

Nocera, S., Pungillo, G., Bruzzone, F. (2020). How to evaluate and plan the freight-passengers first-last mile. *Transport Policy*, DOI: 10.1016/j.tranpol.2020.01.007.

Rodríguez, D. A. & Joo, J. (2004). The relationship between non-motorized mode choice and the local physical environment. *Transportation Research Part D: Transport and Environment*, 9 (2), 151–173, DOI: 10.1016/j.trd.2003.11.001

Sanko, N. & Shoji, K. (2009). Analysis on the structural characteristics of the station catchment area in Japan. In J. Preston, K. Jansson, & W. Veeneman (Eds.), Proceedings of the Eleventh International Conference on Competition and Ownership in Land Passenger Transport: Public Policy and Transport (pp. 79–86, Delft).

Santoso, D. S., Sakamoto, K., Yajima, M., Kubota, H. (2015). Trip characteristics of commuters accessing rail transit by considering distance and slope with integration of public

bus as a feeder. *Journal of the Eastern Asia Society for Transportation Studies*, 11, 1479–1494. DOI: 10.11175/easts.11.1479

Su, F., Schmöcker, J., Bell, M. (2009). Mode choice of older people before and after shopping: a study with London data. *Journal of Transport and Land Use*, 2 (1), 29–46.

van Soest, D., Tight, M. R., Rogers, C. D. (2020). Exploring the distances people walk to access public transport. *Transport Reviews*, 40 (2), 160–182, DOI: 10.1080/01441647.2019.1575491

Wardman, M. Chintakayala, V. P. K., de Jong, G. (2016). Values of travel time in Europe: review and meta-analysis. *Transportation Research Part A: Policy and Practice*, 94, 93–111. DOI: 10.1016/j.tra.2016.08.019

Young, M. & Blainey, S. (2018). Railway station choice modelling: a review of methods and evidence. *Transport Reviews*, 38 (2), 232–251, DOI: 10.1080/01441647.2017.1326537