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School Commuting: Barriers, Abilities and Strategies toward Sustainable Public Transport Systems in Yogyakarta, Indonesia

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Abstract: This study aims to investigate students' difficulties in using the bus to get to school based on Rasch analysis and examines students' innate abilities in handling the barriers. A total of 536 high school students in Yogyakarta were randomly surveyed. This study considers forty barriers of bus use grouped into eight aspects: safety, bus stop reliability, accessibility, mobility, payment system, bus reliability, transfer efficiency, and information and communication technology. The results show that the students experienced 18 main barriers in using the bus. The limited time of travel, circuitous routes, and distance to the bus stops were the three most significant barriers for students in using the bus during the morning commute. Conversely, students reported no difficulty using the bus regarding safety and payment system aspects. This result additionally shows that gender, age, allowance, and drivers' licenses also influence the extent of the barrier experienced by the students. Finally, some strategies to increase the students' ability to overcome barriers in utilizing the bus are proposed to create a sustainable public transport system in Yogyakarta.

Keywords: barrier; trips to school; public transportation; students

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1. Introduction

To encourage public transport use, Yogyakarta has upgraded the city bus performances by expanding bus routes, adding more vehicles and stops, and improving the service quality. Since 2008, a BRT-like system has been in operation, which as of 2021 has 20 routes and 172 bus fleets. As a result, public transport use is expected could reduce emissions and road accidents [1,2]. Dirgahayani found that shifting from private motorized vehicles to bus use in Yogyakarta could potentially reduce 3362.65 tons of PM_{10}; 1423.75 tons of SO_2; 1,313,016 tons of CO_2; 61,288.72 tons CO; and 19,645.79 tons of NO_x [3]. However, a study in 2019 showed that the comparison between the number of bus passengers and bus capacity (i.e., bus load factor) in Yogyakarta is merely 17.35% [4]. In addition, the number of motorized vehicles, especially motorcycles, continues to increase every year. For example, in 2019, the number of motorcycles in Yogyakarta increase about 30% from the previous year [5].

Students are the most frequent bus passengers in Yogyakarta, with official data from the Transportation Agency of Yogyakarta showing that students dominate bus users by 34%, followed by workers and entrepreneurs, accounting for 26%, respectively [6]. However, public transport is not the main travel mode among students. Primary, junior and high school students are commonly driven to and picked up from school by their family members using private vehicles. Meanwhile, most senior high school students choose to ride motorcycles on their commute to school [7]. A survey of bus use frequency shows that nearly 63% of students aged 13–15 years old in Yogyakarta never use public transport. Only 5% of them use public transport daily [8]. In addition, the emergence of ride-hailing services in the last decade has had a direct impact on the decline in public transport use in Yogyakarta [9].

Examining students' travel is crucial to supporting sustainable urban transport. Once we understand this demographic's barriers to using public transport, policies can be proposed to encourage them to use public transport by suppressing the barriers, hence, nurturing good habits early and stimulating them to keep using public transport in the future. Due to this, the objectives of this study are as follows: (1) to investigate the factors that become barriers in using the bus as a means of traveling to school in the morning; (2) to measure individual capability in tackling the barrier encountered during school trips by bus, and (3) to understand how sociodemographic factors affect the abilities to overcome barriers. To accomplish this, a Rasch model was performed by considering 40 barriers of bus use categorized into eight aspects, including safety, bus stop reliability, accessibility, mobility, payment system, bus reliability, transfer efficiency, and information and communication technology. With the Rasch method, barriers encountered by the subjects in using the bus are considered as latent variables that demonstrate unobservable and unmeasurable characteristics. In addition, the Rasch model is also able to compare the difficulty level in using the bus and individuals' ability to overcome the difficulties via an item –person map.

This study has important theoretical and practical implications. First, from an academic perspective, this study adds new insights to the sustainable urban transport literature, which mainly focuses on understanding the factors influencing public transport use without considering and measuring passengers' ability to respond to those influencing factors. In addition, sustainable urban transport in Southeast Asia may have different characteristics from Western countries. Thus, it is reasonable to hypothesize that passengers in Southeast Asia, such as Indonesia, may encounter public use barriers differently than those in Western countries. Second, from a practical perspective, this study contributes by proposing effective and suitable policies for governments aiming to encourage students to use the bus on their school commuting trips. Since studies in sustainable transportation are rare in the forecasting and policy evaluation, this study attempts to fill this gap by simulating the impact of policies designed to overcome the students' difficulties on school commuting by bus. With depleting barriers in using buses, it is hoped that more students will elect to use public transport to get to school. The lessons learned from Yogyakarta can also be extended to other Indonesian cities since, although each city is unique, they had similar problems. A BRT-like system has been operated in other Indonesian cities such as in Solo [3], Semarang [10], Bandung [11], and Banda Aceh [12], and encountered similar issues related to the low demand, service standards, and students who dominate as bus users.

2. Literature Review

An extensive literature review regarding travel behavior and mode choices decision was performed. Herein, the current understanding of the effects of several factors regularly included in public transport use is discussed. Previous studies show that quality of service is one of the main factors that affect an individual's usage of public transportation. Chica-Olmo et al. expressed that the significant components that play a role in bus service are comfort, bus schedules and frequency, bus stop location, and bus route [13]. Meanwhile, according to Mahmoud and Hine, key indications on service quality include frequency, reliability, waiting time, bus stop or bus station safety, bus stop location, convenience on the bus, availability of ticket discounts, bus tariffs, transfer needs, and accessibility to park-and-ride facilities [14]. Furthermore, a study on public transportation users among university students in eight cities in Europe indicates that punctuality is the most important aspect for those students when using bus service from homes to their university. A third of the respondents expressed that they would pay higher fares for a reliable and on-time service [15].

Accessibility has consistently been shown to be associated with the use of public transportation [16]. The more easily a person can reach public transportation infrastructures such as bus stops, stations, and terminals, the higher the probability of using this particular public service [17,18]. A similar result was also found by Ovidio et al., who state that accessibility is a significant dimension of public transportation service quality [19]. Additionally, the amenity of accessibility implies passengers' satisfaction in using public transportation [20], and the positive experience in using public transportation engenders loyalty in public transportation users [21]. Furthermore, environmental aspects such as environmental quality and population density also influence the feasibility of access [22]. Chakrabort and Mishra established that higher population density supports a higher interest in public transportation in their study. The tendency of higher environmental quality in high-density locations also provides safer surroundings and better facilities, resulting in tremendous enthusiasm for using public transportation facilities [23].

Sociodemographic attributes such as age and gender are also typically included in public transport studies as influence factors. For example, boys and older children tend to use public transport [24]. A study also found that boys in Beijing, China, use the bus more often than girls due to parental anxiety about child safety [25]. Household characteristics such as income and vehicle ownership also affect bus use among children. Previous studies found that children with high socioeconomic status are more likely to be escorted by their family members rather than using public transportation [25]. This finding is in line with another study in the Netherlands and Flanders showing that children from high-income households and having more private vehicles are less likely to use public transport [26]. However, a study on travel to school in Florida found that income and vehicle ownership in a household did not correlate to mode choice between bus and automobile among children [27]. In addition, the travel patterns of parents also determine the children's travel mode. For example, a study stated that if parents use cars or motorcycles for their commuting trips, the likelihood of taking their children to school by private vehicles increases [28]. Meanwhile, Yan found that journey-to-work patterns significantly influence the mode choice decision in Shanghai [29]. Lin and Chang also stated that when the location of the children's school is close to parents' offices or located along the parent's travel route, parents tend to escort their children to school by private vehicle on the way to the workplace [30].

Furthermore, with the rapid growth of information technology and communication (ICT), the benefit of ICT use, especially in smartphone applications among students, also plays an essential role in mode choice of travel and departure time and their pattern of travel [31]. A previous study also shows that easily accessible real-time public transportation arrival information can increase passengers [32]. Meanwhile, another study indicates that unlimited access to public transportation use, such as discounted fares, could increase the number of university students using public transportation [33]. Furthermore, according to Ly and Irwin, students view discounted tariffs as a facility for active transport, making them walk to and from bus stops, further persuading them to choose public transportation rather than using their own vehicles [34].

Although not focused on school trips, some works also have explored the factors influencing public transportation use in developing countries, especially in Indonesian cities. A study conducted in Jakarta, Indonesia's capital city, showed that safety, comfort, and convenience were powerful stimulants to Trans Jakarta BRT usage [35]. Another study in Jakarta found that type and frequency of activity, and sociodemographic attributes also significantly impact public transportation use, including BRT and paratransit [36]. By focusing on workers and students, one study also attempts to analyze the effect of secondary activities and travel experience during a morning commute on BRT-like usage in Bandung [37].

To the authors' knowledge, literature on school trips in Indonesian cities is limited. In addition, studies linking students' ability to overcome the barriers to school commuting by public transportation remain scant. Thus, this study attempted to fill in these identified research gaps.

3. Study Area

Yogyakarta is an educational city and is located in the south-central part of Indonesia. Yogyakarta extends over 46 km^2 and consists of 14 sub-districts. In 2020, the resident population was 373,589. This city becomes the thirty-sixth largest city among 98 cities in Indonesia [5]. Of the total population, 79,416 of them (21.26%) are populated by people aged 5–19 years old, which can be considered as school-going age. Yogyakarta suffers a chronic problem related to traffic congestion, especially during morning peak hours. Although there is a good public transport system, public transport is an unpopular travel mode during commuting trips, since this mode cannot compete with motorcycles. In addition, almost all households in Yogyakarta owned a motorcycle. In 2020, the number of private motorized vehicles was 533,027, consisting of 465,949 motorcycles and 67,078 cars, and it was higher than the population number in Yogyakarta. Furthermore, the absence of travel demand management, such as the restriction of private motorized vehicle movement and ownership, makes the population less willing to use public transport to fulfill their daily lives.

4. Research Method

4.1. Theoretical Background

The Rasch model was applied in measuring barriers experienced by students while traveling to school using the bus. This model consists of the index level of item difficulty (βi) and the ability of respondent parameter (θj). Within the Rasch model, student ability (θj) and barrier item (βi) are calibrated on the same scale. The principle of this model is a probabilistic model. Log probability chance on a student to responding in the category of k item i (P_{jik}) compared to the category $k-1$ (P_{jik-1}) is categorized as a linear function from the student's competence (θ_j) and the relative category parameter k for item i (β_{ik}), and is formulated in Equation (1) as below:

$$ln\left(\frac{P_{jik}}{P_{ji(k-1)}}\right) = \theta_j - \beta_{ik} \tag{1}$$

Then, by using the Partial Credit Model where each item i has a threshold parameter of its own barrier level F_{ik} for each category k; therefore, Equation (1) becomes Equation (2) as follows:

$$ln\left(\frac{P_{jik}}{P_{ji(k-1)}}\right) = \theta_j - \beta_{ik} - F_{ik} \tag{2}$$

The Rasch model also provides an item–person map representing the distribution between the barrier and students' ability. This map shows information of cross-comparison between student and item parameters. Both student and item parameters are placed continuously by using the same logit. Within the item–person map, the distribution of difficulty level is on the right side, and students' ability is on the left side. The levels of student's ability and difficulty are in order from top-to-bottom. If a student is located in a higher position along the vertical axis, it indicates that her/his ability was relatively high. Similarly, if an item is located at a higher position, it will be a tougher action for students to achieve. A specific item is considered relatively easy to achieve if most of the students' abilities are located at positions higher than the difficulty measure of an item. In a case where a student and an item are located at the same level on the item–person map, he/she will have a probability of 0.5 to achieve this item.

4.2. Sampling and Survey Design

Sample collection was carried out by dividing the respondent population into junior- and senior high school students. The data were collected by using one-stage cluster random sampling. First, we determined that the number of respondents is 536 students. Data were randomly taken in all sub-districts in Yogyakarta. Then, we determined the sample fraction, i.e., a ratio between the sample size and total population, is 0.02163. Finally, we determined the number of the sample in each sub-district with the sample fraction obtained in previous steps.

After the number of the sample in each sub-district was obtained, the surveyors randomly went to one to three schools in each sub-district. The surveyors intercepted the students to interview during the break times at school. The surveyors first confirmed to students whether they fulfill the requirements as a respondent. The initial requirements as a respondent are their home is located at a minimum of five kilometers from school, and their school trip can be accessed with the existing bus service.

The respondents were asked about the barriers or difficulties that they encounter while using buses for their school trip using a five-point Likert scale, starting from 1 for strongly disagree to 5 for strongly agree. As shown in Table 1, there were 40 barriers to public transportation use asked the respondents. Aiming to reduce the difficulty faced by respondents in answering the questions, those barriers are categorized into eight aspects referring to previous studies and asked to respondents in a sequence. After the questions related to the difficulties faced during school commuting by bus were completed, respondents were then interviewed on their demography, such as age, gender, allowance, drivers' license ownership, and the number of family members at home.

Table 1. Questionnaire item in measuring student barriers to using buses for school trips.

Aspects	Variables
Safety	Walking to the bus stop is unsafe because of traffic conditions (X1) Waiting at the bus stop is unsafe because of the high platforms (X2) Waiting at the bus stop is unsafe due to crime (X3) Entering and exiting the bus is unsafe because of the high platform (X4) Traveling by bus is unsafe because the drivers are reckless (X5)
Bus Stop Reliability	Bus stop has no bus arrival-time information (X6) Bus stop is unclean (X7) Bus stop is mixed with a pedestrian path (X8) Bus stop has no seat (X9) Bus stop has no roof and is unprotected from the weather (X10)
Accessibility	Distance from home to bus stop is far (X11) Footpath from home to bus stop is poorly maintained (X12) Distance from bus stop to school is far (X13) Footpath from bus stop to school is poorly maintained (X14) Limited shade trees on route to and from the bus stop (X15)
Mobility	Bus service is unreliable in many places that must be visited during the day (X16) Bus service is unreliable, resulting in potential late arrival at school (X17) Bus service is unreliable, making bringing school equipment difficult (X18) Bus service is unreliable related to limited time for travel (X19)
Payment System	Bus fares are expensive (X20) No attractive discount for students (X21) No membership cards for students (X22) Cash payment system is inconvenient (X23) Card payment system is unreliable (X24) Card top-up system is unreliable (X25)
Bus reliability	Bus is crowded (X26) Bus frequently gets stuck in traffic jam (X27) Bus route is slow/circuitous (X28) Bus has limited seating (X29) Bus interior is hot and/or humid (X30) Bus is poorly maintained (dirty, smelly) (X31) No information about bus stops and routes inside the bus (X32) Bus staff is unfriendly and/or unhelpful (X33)
Transfer efficiency	Bus transfers are difficult (X34) No information on transfer points is available (X35)

Table 1. *Cont.*

Aspects	Variables
Information and Communication Technology	Bus has no supporting mobile phone application (X36) Bus location cannot be tracked (X37) Bus do not have priority at intersections (X38) Bus and bus stops have no internet access or WiFi (X39) Bus and bus stops have no closed-circuit television (X40)

5. Analysis Results

5.1. Descriptive Analysis

The survey subjects were predominantly female (61.9%). Respondents under 16 years of age made up 57.5%, and those over 16 made up 42.5%. There were 267 middle school students (49.8%) and high school students, with a total of 269 (50.2%). The majority of students (295 individuals, or 55%) receive an allowance ranging from 15,000 to 30,000 rupiahs per day, with those who receive less than 15,000 rupiahs per day as an allowance accounting for 40.9%. The rest (4.1%) receive more than 30,000 rupiahs per day. It should be noted here that at the time of the research in August 2020, 1 USD equals 14,925 rupiahs.) Finally, 57.6% of the subjects have more than four family members in their household. Interestingly, 82.5% of respondents admit that they do not own a motorcycle driving license.

5.2. Reliability Test, Ranking Scale Validity and Unidimensionality

Based on the analysis result of WINSTEP [38], it is known that the Cronbach Alpha reliability coefficient value, which determines the interaction between an individual with item entirety, is included with the category of excellent, which is 0.92. As seen from the item reliability value, the item quality queries prove to be an exceptional instrument (0.99), whereas the person reliability value is 0.91, meaning the consistency of respondents' answers within this research is very good. Overall, the measurement result in this investigation is valid.

Meanwhile, the comparison result between the observed average and Andrich Threshold value used in the verification of assumption level given in the instrument shows that the choice rating given to respondents was clear. The observed average value starts with −1.05 logit for score option 1, then increases with score option 2 to −0.50 logit, increases more with score option 3 of −0.03 logit, score option 4 with 0.50 logit lastly score option 5 with a logit score of 1.04. With the Andrich Threshold moving from negative value moving toward positive value sequentially, it shows that the options given to respondents are valid.

The one-dimensionality test is used to identify the latent traits of all measured questions [39]. To measure the raw variance, this investigation utilized the Principal Component Analysis. Data from the raw variance equation result are 40.5%. This shows that the one-dimensionality requirement, which has to be a minimum of 20%, is fulfilled. Furthermore, ideally, variance from the instrument should not exceed 15%, and from the result derived all measures under 10%. Based on this, the diversity in this instrument is fit.

5.3. Item Suitability Level

One way to check items and respondents in the Rasch model is by using item fit from the value of outliers or misfits. Outfit Mean Square value (MNSQ), Outfit Z-Standard (ZSTD) are criteria used to examine the level of item fit [40,41]. Item fit indicator for all barriers are MNSQ ($0.5 < MNSQ < 1.5$); ZSTD ($-2.0 < ZSTD < 2.0$). While evaluating items, it is recommended to identify outfits rather than outfit MNSQ. This is on the foundation that outfit statistic is more sensitive than the outlier. Other than that, outfit sensitivity results in easier item identification and better resolve problems. MNSQ is a chi-square equation, measuring the association level for the outfit and infit statistics; meanwhile, ZSTD is a t-test statistic evaluation, measuring existing MNSQ probability. As the ZSTD value is based on MNSQ [38], the initial step of evaluating item fit is to examine MNSQ. After evaluating MNSQ outfit value, it is assessed whether MNSQ value is compatible with the fit range.

If not, specific responses from each respondent that causes the item to be incompatible should be reviewed, then the MNSQ value rechecked. As long as the MNSQ value is within the range of compatibility indicator of item fit, which is MNSQ (0.5< MNSQ < 1.5), then the ZSTD value can be omitted [40]. The result calculation of MNSQ, ZSTD, and Point Measure Correlation value can be seen in Table A1 in the Appendix A.

The outfit and infit MNSQ are between 0.5 up to 1.5. The highest outfit MNSQ value is 1.49 at item 16 and the lowest at item 7, with a value of 0.65. Since the MNSQ value is compatible with the criteria, ZSTD can be ignored so that items used in this research, which are barriers experienced by students in using public transportation, are fitted (item fit) and can describe the actual situation. Furthermore, Point Measure Correlation is ranging from 0.31–0.64. This value is nearing the ideal value due to its positive value and not close to zero.

5.4. Barrier Value Parameter Estimation

The item parameter estimation is shown in Table A1 in Appendix A, representing the extent of barriers experienced by students using buses as part of their school trips in the morning. The highest parameter value depicts the most difficult barrier. The logit value higher than 0 shows that students had difficulty in overcoming barriers related to the item, making it a priority to solve. Eighteen barriers were considered difficult for students. The most challenging barrier during the bus trip is shown by the highest logit value of 1.24, which is the limited time for travel. This barrier most likely occurs during the morning, as school starts at 7 AM. This result is consistent with a previous study showing that high school students who choose to use the bus for trips to school must depart much earlier than those who use motorcycles 30]. As many as 17 relatively difficult barriers have the logit value of 0.14 up to 1.17, which are item 28 (bus route is slow/circuitous), item 11 (distance from home to bus stop is far), item 39 (bus and bus stops have no internet access), item 27 (buses stuck in traffic jams), item 29 (buses have limited seats), item 37 (bus location cannot be tracked), item 18 (bus service is unreliable related to hassle in bringing school equipment), item 34 (bus transfers are not seamless), item 26 (bus is crowded), item 15 (limited shade trees to and from the bus stop), item 40 (bus and bus stop have no closed-circuit television), item 6 (bus stop has no bus arrival information), item 38 (buses do not have priority at intersections), item 36 (bus has no supporting mobile phone application), item 16 (bus service is unreliable in many places that must be visited during the day), item 5 (traveling by bus is unsafe because the drivers are reckless) and item 35 (no information on transfer points is available), ordered form the most to the least.

Based on the eight aspects under review, barriers related to information and communication technology have the highest average barrier value of 0.56, making students unwilling to use the bus. The average barrier value of mobility, transfer efficiency, bus reliability, and accessibility, from the lowest to the highest, are 0.36 logit, 0.35 logit, 0.25 logit, and 0.09 logit, respectively. Meanwhile, a logit value less than 0 shows that the barriers students face were easy to overcome. On average, students have no difficulty in using bus mode in barriers related to bus stop reliability, safety, or payment system, since those aspects' logit values are lower than zero (i.e., -0.08 logit, -0.55 logit, and -0.71 logit, respectively). Item 20 has the lowest logit value with the item estimation of -1.38, which shows that bus fares are affordable and therefore not a barrier to riding the bus. As many as 21 barriers had a low level of difficulty to overcome with the logit value of -0.11 to -1.19.

5.5. Student Ability Estimation Parameter

Individual parameter estimation is represented by the value θ_i. This shows an individual's capability in tackling the barrier that they encounter during bus use to school. The highest θ_i value describes the best ability for students to overcome barriers. Individual parameter estimation for some students is shown in Table 2. The raw score of each student has been adjusted to students' capability in handling barriers in logit scale. Within this investigation, student ability measurement estimation ranges from 3.21 logit until

−2.57 logit. The highest θ_i value demonstrates the highest student ability, which is student 23 with the value of 3.21 logit, whereas student 181 has the lowest ability in overcoming barriers to using the bus with −2.57 logit. The mean of student ability estimation is valued at 0.02 logit. Two hundred fifty-five students have above-average scores, while the rest have lower than average scores. Therefore, most students are considered to be unable to overcome barriers.

Table 2. Student ability estimation parameter.

Student	Raw Score	θ_i
23	190	3.21
132	181	2.39
349	181	2.39
35	173	1.90
62	173	1.90
10	172	1.84
...	...	...
...	...	...
395	66	−1.91
490	65	−1.96
491	59	−2.19
449	57	−2.33
91	57	−2.43
181	55	−2.57
Mean		0.02
Standard deviation		0.67

An advantage of the Rasch model is that respondents' ability can be compared with barrier difficulty level, enabling the research to examine the number of students capable of successfully overcoming barriers to using the bus. From Figure 1, it is shown that 13 barriers were overcome by 75% of students. However, only 25% of students were able to overcome 12 other barriers. Furthermore, the seven most difficult barriers were only solved by 10% of students, roughly 50 from a total of 536 respondents. Twenty-two obstacles were solved by 50% of students, but fewer than half could solve the other 18 barriers. More than 90% of students were able to resolve the five barriers they encountered. Hence, actions must be made to eliminate the barriers experienced by these students.

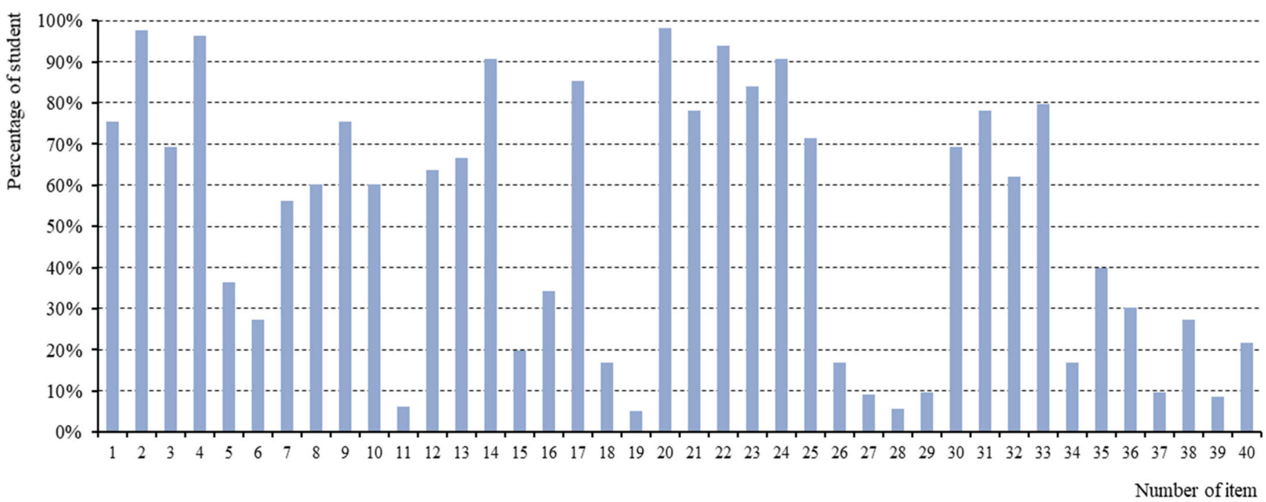


Figure 1. Percentage of students' ability to overcome the barriers.

5.6. Individual Item Map (Barrier vs. Ability)

Figure 2 shows the person-item map. If seen from the dispersal of the item, the range of student ability is more diverse than the range of barriers, explaining that students' capability varies, some having a high capability to overcome barriers, but conversely, some have difficulties shown by their low position. Generally, student ability is distributed normally. However, on the student ability dispersal, student peak or cluster is located under the average, indicating that most students experience barriers in using public transportation. On the item and person part of the diagram, each has the notation "M", "S" dan "T" which reveals the average difficulty, one standard deviation, and two standard deviations. Grouping can be based on utilizing the two notations to very easy, easy, difficult, and very difficult barriers. A very easy barrier is located at S to T with less than 0 logit, consisting of 6 items (15%): X20, X2, X4, X22, X14, and X24; the easy barrier is located at M to S with less than 0 logit, consisting of 16 items (40%): X17, X23, X21, X1, X25, X31, X33, X9, X13, X10, X3, X30, X12, X32, X7, and X8. Then, the difficult barrier is located at S to M with more than 0 logit consisting of 11 items (27.5%): X18, X34, X15, X26, X40, X16, X36, X38, X5, X6, and X35. Lastly, a very difficult barrier is located at T to S with more than 0 logit consisting of 7 items: X19, X11, X28, X27, X29, X37, and X39.

5.7. Different Student Barrier in Using Public Transportation for School Trips Based on Demographic Characteristics

After barrier and students' ability parameter values have been successfully obtained, the next step is to contrast between groups. A comparison between these groups is intended to discover students' ability to overcome barriers according to their characteristics. A group difference test was carried out prior to investigating the different barriers experienced by students from a range of demographic groups. The grouping was based on allowance, gender, age, number of family members, parents' occupation, and drivers' license ownership. The results of the group difference test are exhibited in Table 3.

Table 3. Group difference test.

Variable	Group	Total	Mean	*p*-Value
Allowance (IDR)	<15,000	219	0.1280	0.000 *
	15,000–30,000	295	−0.0315	
	>30,000	22	−0.4441	
Gender	Male	204	0.1283	0.001 *
	Female	332	−0.0518	
Age	<16 years	308	0.1250	0.000 *
	≥16 years	228	−0.1295	
Number of family members in a household	≤4 people	309	−0.0271	0.079
	>4 people	227	0.0763	
Motorcycle driving license ownership	Yes	93	−0.2898	0.000 *
	No	443	0.0811	

* means that *p*-value less than 0.05.

Based on Table 3 above, it can be determined that demographic characteristics have a significant difference among some groups with a confidence level of 95%. Gender variable (p = 0.001), age (p = 0.000), allowance (p = 0.000), and driving license ownership (p = 0.000) have significant difference for students to overcome the barriers during public transportation use. Commonly, female students (−0.0518 logit) have lower competence than male students (0.1283 logit) in solving barriers. Additionally, students under the age of 16 years old (0.1250 logit) have higher competency in using bus mode rather than students above 16 years old (−0.1295 logit). Students who do not own a motorcycle driving license (0.0811 logit) exceed more than those who own a motorcycle driving license (−0.2898 logit) in handling circumstances. Next, students having less than IDR 15,000 per day for an allowance (0.1280 logit) have the highest achievement in solving barriers while using bus mode rather than students having an allowance higher than IDR 30,000 per day

(−0.4441 logit) and between IDR 15,000 to IDR 30,000 per day (−0.0315 logit). Meanwhile, the number of students' family members does not play a significant role in each sub-group.

To recognize barrier items affecting students' difficulty in using bus mode from a range of groups, a differential item functioning (DIF) analysis is necessary for which applies when item functions differently toward students from different groups. Previously, difference tests showed that barriers experienced by students vary from gender, age, allowance, and driving license ownership. Table A2 in the Appendix A displays the DIF measure and *p*-value from each item on the significant difference variable.

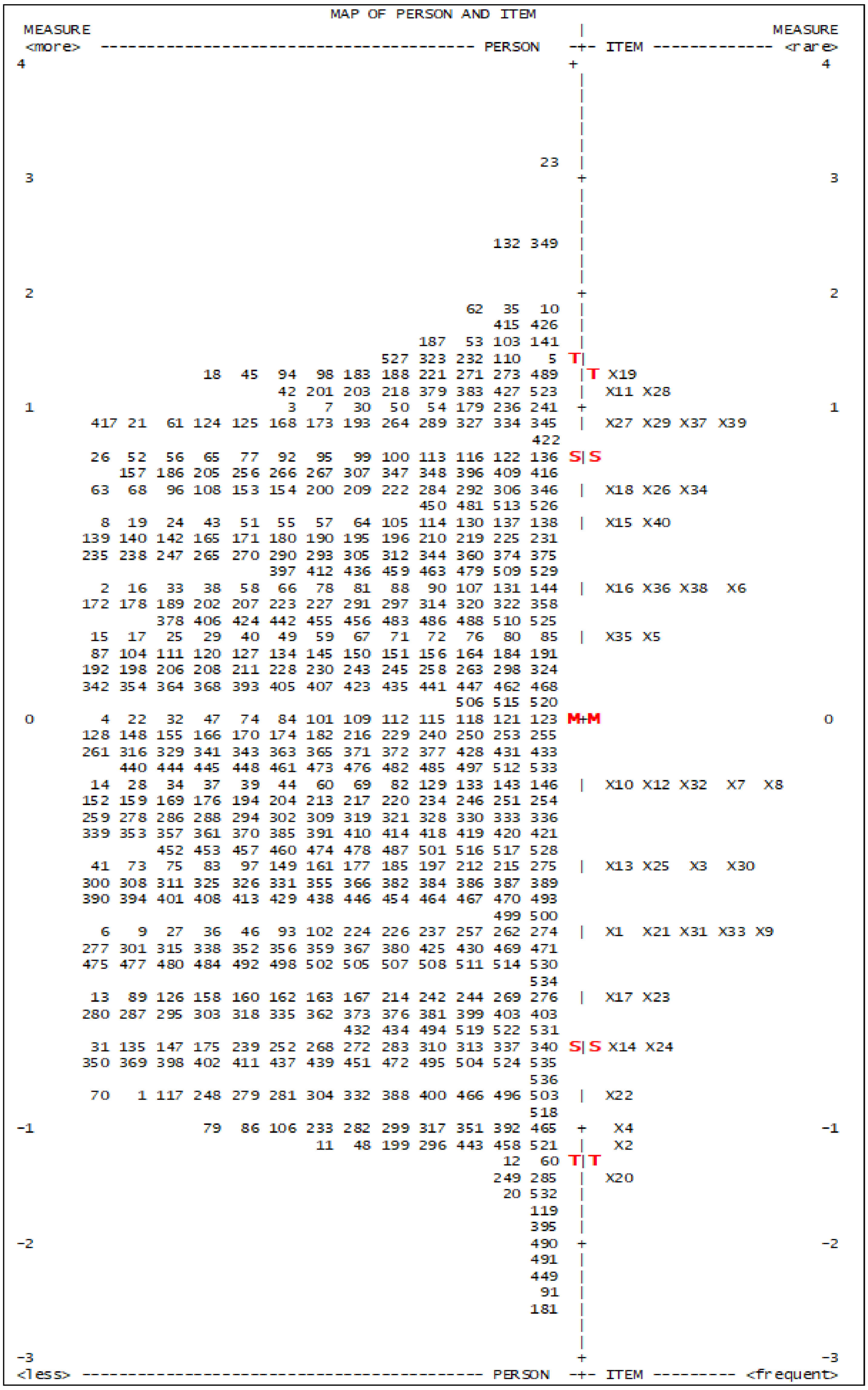


Figure 2. Map of barriers—student's ability.

Seen from the DIF-contrast value, based on the gender variable, the item waiting at the bus stop is unsafe, walking to the bus stop is unsafe, waiting at the bus stops is insecure, and entering to or exiting from the bus is unsafe are major items considered the determinant of male and female difference. Meanwhile, based on the age variable, walking to bus stop is unsafe, waiting at the bus stop is unsafe, entering to or exiting from the bus is unsafe to become the differentiating barrier. Students aged less than 16 feel that those barriers are more difficult to overcome than students aged more than 16. This can be grounded in the fact that students aged less than 16 are in the transition stage of becoming young adults, influencing their emotional instability, including ignoring safety. However, items 16, 17, and 19, which are many places to stop by within a day, estimated time of arrival at school is unpredictable, and travel time limitations are felt more significantly by students over the age of 16 compared to students under 16. This is due to the busier schedule of students aged over 16, such as extra courses, going to the bookstore, hanging out with friends, picking up family members so that they have limited time, and many places to get to.

The barrier difference of the allowance variable has the most DIF-contrast value which is derived from the item no available WiFi at buses and bus stops. Students with an allowance less than IDR 15,000 per day (1.10 logit) feel that the barrier of no WiFi at buses and bus stops is difficult compared to students with IDR 15,000–Rp 30,000 per day (0.79 logit) and students with an allowance of more than IDR 30,000 per day (0.45 logit). This can occur due to the financial strain of students who bring less than IDR 15,000 per day for their allowance, which they would allocate for basic needs instead. On the contrary, students having more than IDR 30,000 per day for their allowance can use it for the internet so that they do not depend on WiFi. Furthermore, the barriers of many places to stop by in a day and having to change bus routes are felt by students with a driver's license rather than those who do not have one. This may occur because students with a driver's license enjoy a much higher degree of mobility.

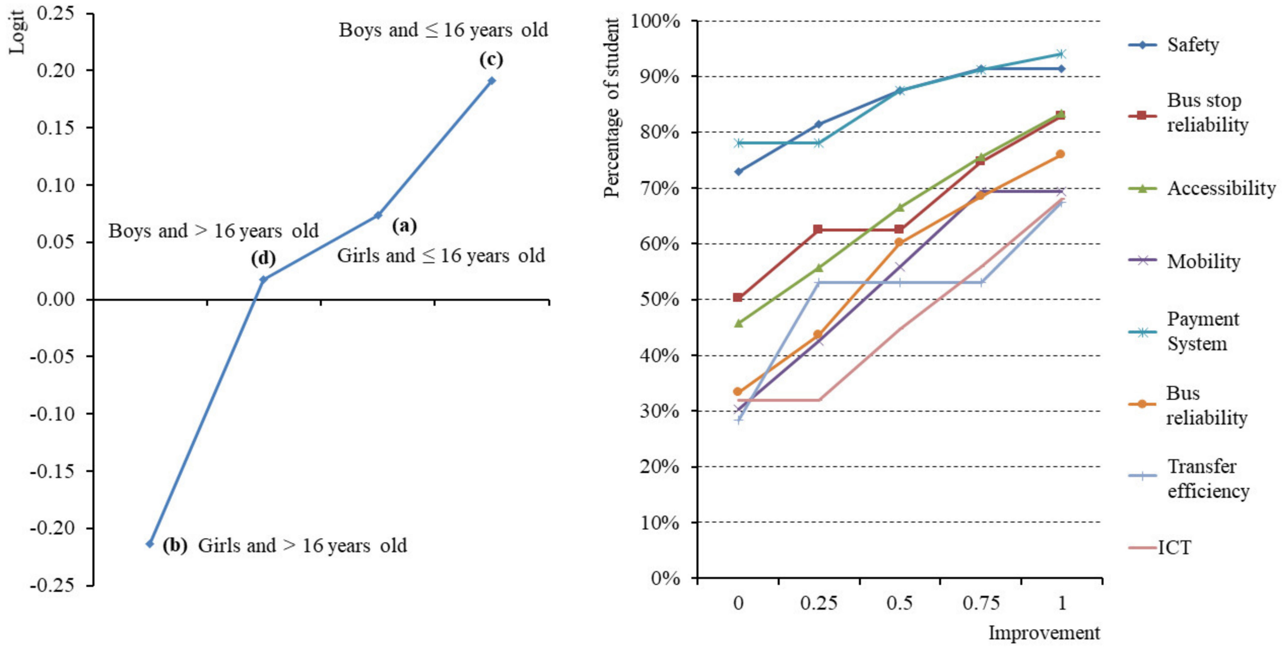
6. Policy Analysis

To target efficient group handling, deeper student ability identification in handling the difficulty of using the bus is carried out with sociodemographic features. Then, this study classifies for categories based on the combination of two features, gender and age, as: (a) female students under 16 years, (b) female students 16 years or older, (c) male students under 16 years and (d) male students 16 years or older.

Figure 3a illustrates that group ability as c > a > d > b. This shows that the ability of students under 16 years is the highest achieving compared to other groups. Next, if (a) and (b) are contrasted where both groups are female, students under 16 years can better overcome barriers. Then, when group (a) and (c) (female and male students under 16, respectively) are compared, girls tend to have lower ability than boys in handling barriers. Seen from the group (a) and (b) ability discrepancy, and group (a) and (c), a vertical gap can be seen between (a) and (b), which is wider than group (a) and (c). The group (a) and (b) vertical gap demonstrates the effect of age, whereas (a) and (c) represent the effect of gender. This reveals that age is more effective in advancing students' ability in handling barriers. Due to this, designing programs for resolving barriers aimed at students under 16 years should be more efficient rather than other student groups, for escalating bus use interest for students.

Furthermore, there are two approaches to reduce students' difficulty in using the bus to get to school. Firstly, it is to improve students' capability in handling barriers, and secondly, to reduce the possibility of these barriers. Effectivity in the increase of each effect of barrier handling is shown in Figure 3b. The increase of barrier handling is represented in the x-axis, while the y-axis shows the percentage of students who successfully overcome the barriers. Figure 3b further portrays barrier handling focused on five aspects where students' ability in overcoming barriers is below 50%, which are accessibility, bus stop reliability, transfer efficiency, mobility, and ICT. With the same barrier handling increase, the aspect of bus reliability plays the highest effectivity in raising student ability in handling barrier.

This is pointed out in zero logit position, where student capability in overcoming barriers in the aspect of bus reliability is merely 33%, and when the handling barrier is increased to 0.5 logit, the number of students who are able to overcome barriers ascend to 60%. When logit is added to 1, the percentage further escalates to 76%. Compared to the other four barrier aspects, the aspect of bus reliability can increase to 43% of students in handling barriers when the barrier level is decreased to 1 logit. Among the five aspects, depleting barriers on accessibility and bus reliability could become the priority in managing barriers due to more effective performance.



(**a**) (**b**)

Figure 3. (**a**) Students' ability based on age and gender (**b**) Effectivity in barrier handling increase of each aspect.

7. Conclusions

This study aims to identify factors that become barriers for students to use the bus in Yogyakarta, Indonesia, and measure the students' ability to overcome the obstacles. This study contributes to the current literature in terms of theoretical implications. To the best of our knowledge, this was the first study in developing countries to apply the Rasch model in examining the decision to use public transport as a sustainable urban transport on morning school commuting. Out of 40 estimated barriers due to bus use among students, we found that students experience 18 barriers when using the bus for their morning trip to school. The barriers consist of one factor related to the aspect of bus stop reliability (bus stop has no bus arrival information), two barriers related to the aspect of accessibility (distance from home to the bus stop and limited shade trees to and from the bus stop), three barriers related to the aspect of mobility (limited time for travel, difficulties in bringing school equipment, unreliable service to the places needed to go during the day), five barriers related to the aspect of bus reliability (i.e., slow/circuitous bus routes, buses often stuck in traffic jams, limited seating, crowding, reckless bus drivers), two barriers related to the aspect of bus transfer (bus transfers are not seamless, no information is available related to transfer points), and five barriers related to the aspect of ICT (no internet access inside buses and bus stops, bus location cannot be tracked, buses and bus stops have no closed-circuit television, buses do not have priority at intersections, buses have no supporting mobile phone application).

Furthermore, by using DIF analysis, it has been discovered that there are differences between barriers being experienced based on demographic factors such as gender, age, allowance, and driving license ownership. As an example, girls have a lower ability to overcome barriers compared to boys. Students under 16 have a higher capability for overcoming barriers than those older than 16 years. Other than that, students with less than IDR 15,000 per day for their allowance have a higher ability to solve barriers to using the bus compared to those having more than IDR 30,000 per day and those having between IDR 15,000 to 30,000 per day for their allowance.

For the practical contributions, this study could be helpful to policymakers in developing strategies for increasing students' interest in using the bus. Relating to service reliability, an important step to achieve is for the bus operator to increase journey reliability by effectively cutting travel time. This can be solved by adding more buses at peak hours and bus priority management, such as bus prioritization at signalized intersections. With an increased number of vehicles in the fleet, headway can be reduced, solving barriers on the limited seats and crowded buses. Further, problems concerned with buses getting stuck in traffic can also be cleared by bus priority management. Another barrier related to reliability is the slow/circuitous bus routes, which can be solved by evaluating the existing bus routes. Passengers tend to prefer direct routes, but if route transfer has to be carried out, bus frequency should be higher, and waiting time should be lessened. A similar policy was also proposed by Bastarianto et al., aiming to increase bus use among commuters in Jakarta Metropolitan Area [42]. Second, accessibility should also be improved. The barrier of distance from students' homes to bus stops can be solved by adding bus stops in residential areas and integrating ride-hailing services into the bus system. A study found that motorcycle-based ride-hailing services potentially act as a first-mile and last-mile [43]. Other than that, fixing pedestrian facilities such as sidewalks should increase safety and eliminate sidewalk barriers from home to the bus stop and from the bus stop to school. Lastly is the improvement of ICT in offering greater comfort, safety, and reliability by taking advantage of technology. Providing internet access (WiFi) inside the buses and the bus stops can give added value for students as everything is connected to the internet nowadays. This recommendation is consistent with a study finding in another city in Indonesia, i.e., Bandung Metropolitan Area [37]. They showed that students have more attention to smartphone use during the morning commute to engage in online activities such as listening to music, playing games, and engaging in social media. Therefore, providing WiFi facilities inside the bus could facilitate students to participate in online activities and is expected to stimulate students to use public transport. Another strategy to improve is the accommodation of closed-circuit television inside the buses and bus stops to provide a feeling of security while waiting for the bus. Buses should also be equipped with GPS to enable real-time location services as well as travel time estimations. Apart from the above findings, the government also needs to educate students on the impact of public transport use, given the imperative of sustainable travel generally and getting young people into good habits early. A study found that students in Yogyakarta think that using public transport has no benefits for health and the environment [8]. This phenomenon is inconsistent with the perception of public transport use advantages in developed countries [44,45].

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Data Availability Statement: The data used can be requested from the authors.

Conflicts of Interest: The authors declare no conflict of interest.

Appendix A

Table A1. Parameter estimation value, MNSQ, ZSTD, and Point Measure Correlation.

Item	Estimated Parameter (βi)	Infit		Outfit		Pt Mean Corr
		MSNQ	ZSTD	MSNQ	ZSTD	
X19	1.24	1.10	1.70	1.10	1.70	0.50
X28	1.17	0.88	−2.20	0.85	−2.60	0.57
X11	1.11	1.44	6.80	1.41	6.20	0.44
X39	0.90	1.17	2.90	1.17	2.90	0.35
X27	0.85	0.73	−5.40	0.74	−5.10	0.56
X29	0.82	0.81	−3.60	0.83	−3.20	0.49
X37	0.82	0.94	−1.10	0.93	−1.30	0.49
X18	0.55	1.14	2.40	1.14	2.50	0.51
X34	0.55	1.20	3.60	1.20	3.40	0.53
X26	0.53	0.77	−4.50	0.79	−4.00	0.58
X15	0.48	1.11	2.00	1.13	2.30	0.52
X40	0.46	0.99	−0.20	1.03	0.60	0.47
X6	0.35	1.12	2.10	1.11	2.00	0.54
X38	0.34	0.81	−3.60	0.86	−2.60	0.47
X36	0.30	1.04	0.80	1.07	1.20	0.48
X16	0.22	1.46	7.40	1.49	7.70	0.44
X5	0.19	1.27	4.70	1.30	5.00	0.44
X35	0.14	0.97	−0.40	0.97	−0.50	0.64
X7	−0.11	0.63	−7.80	0.65	−7.20	0.59
X8	−0.13	0.67	−6.70	0.70	−5.90	0.53
X10	−0.14	0.81	−3.70	0.82	−3.40	0.60
X32	−0.17	1.00	−0.10	1.01	0.30	0.56
X12	−0.18	0.95	−0.90	0.96	−0.80	0.51
X13	−0.26	1.50	7.70	1.49	7.50	0.44
X3	−0.28	0.96	−0.70	0.95	−0.80	0.53
X30	−0.29	0.94	−1.00	0.94	−1.10	0.49
X25	−0.31	0.82	−3.30	0.83	−3.10	0.57
X1	−0.38	1.10	1.60	1.15	2.50	0.38
X9	−0.38	0.91	−1.70	0.93	−1.30	0.49
X21	−0.43	1.16	2.60	1.14	2.40	0.50
X31	−0.44	0.73	−5.10	0.74	−4.90	0.58
X33	−0.47	0.70	−5.90	0.70	−5.70	0.57
X23	−0.55	0.85	−2.70	0.88	−2.10	0.55
X17	−0.58	1.42	6.30	1.44	6.50	0.31
X14	−0.72	0.74	−4.70	0.75	−4.50	0.53
X24	−0.72	0.66	−6.50	0.68	−5.90	0.56
X22	−0.85	1.19	3.00	1.17	2.60	0.47
X4	−1.07	1.20	3.10	1.20	3.00	0.38
X2	−1.19	1.02	0.30	1.02	0.40	0.35
X20	−1.38	1.02	0.40	1.04	0.60	0.37

Table A2. DIF Measure and *p*-value.

Item	Gender DIF Measure Male	Gender DIF Measure Female	Gender *p*-Value	Age DIF Measure <16 years	Age DIF Measure ≥16 years	Age *p*-Value	Allowance (Thousand Rupiah) DIF Measure <15	Allowance (Thousand Rupiah) DIF Measure 15–30	Allowance (Thousand Rupiah) DIF Measure >30	Allowance *p*-Value	Driving License DIF Measure Yes	Driving License DIF Measure No	Driving License *p*-Value
X1	−0.600	−0.260	0.0010 *	−0.200	−0.620	0.0000 *	−0.380	−0.410	0.030	0.1980	−0.800	−0.290	0.0001 *
X2	−1.560	−1.010	0.0000 *	−1.020	−1.430	0.0002 *	−1.130	−1.270	−0.900	0.2267	−1.590	−1.110	0.0013 *
X3	−0.420	−0.200	0.0227 *	−0.280	−0.280	1.0000	−0.360	−0.280	0.190	0.0855	−0.440	−0.240	0.1218
X4	−1.200	−1.000	0.0735	−0.820	−1.400	0.0000	−1.010	−1.070	−1.380	0.3803	−1.710	−0.940	0.0000
X5	0.060	0.270	0.0263 *	0.150	0.250	0.2672	0.190	0.240	−0.220	0.1671	0.190	0.190	1.0000
X6	0.410	0.320	0.3259	0.320	0.390	0.4853	0.470	0.290	0.030	0.0759	0.350	0.350	1.0000
X7	0.070	−0.230	0.0020 *	−0.110	−0.110	1.0000	−0.190	−0.060	−0.070	0.4018	−0.190	−0.110	0.5078
X8	−0.080	−0.150	0.4920	−0.080	−0.190	0.2695	−0.170	−0.080	−0.370	0.3581	−0.170	−0.130	0.6661
X9	−0.380	−0.380	1.0000	−0.300	−0.490	0.0556	−0.380	−0.360	−0.630	0.5323	−0.300	−0.380	0.4674
X10	−0.210	−0.100	0.2762	−0.190	−0.070	0.2281	−0.180	−0.140	0.240	0.2500	0.010	−0.170	0.1414
X11	1.070	1.140	0.4888	0.990	1.290	0.0040 *	1.040	1.180	0.870	0.2497	1.160	1.110	0.6959
X12	−0.150	−0.180	0.7246	−0.240	−0.100	0.1373	−0.280	−0.090	−0.470	0.0643	−0.010	−0.220	0.1034
X13	−0.070	−0.370	0.0031 *	−0.200	−0.330	0.1695	−0.260	−0.260	−0.020	0.5827	−0.200	−0.260	0.6172
X14	−0.590	−0.800	0.0449 *	−0.720	−0.750	0.7310	−0.660	−0.760	−0.720	0.6054	−0.610	−0.750	0.2751
X15	0.340	0.570	0.0162 *	0.410	0.580	0.0766	0.380	0.530	0.810	0.1415	0.580	0.480	0.3919
X16	0.370	0.130	0.0139 *	0.020	0.490	0.0000 *	0.090	0.320	0.290	0.0588	0.740	0.120	0.0000 *
X17	−0.520	−0.620	0.3511	−0.410	−0.810	0.0001 *	−0.540	−0.580	−1.130	0.0962	−1.000	−0.490	0.0002 *
X18	0.420	0.630	0.0271 *	0.500	0.620	0.2324	0.470	0.610	0.550	0.3754	0.590	0.550	0.7072
X19	1.140	1.320	0.0960	1.060	1.550	0.0000 *	1.130	1.340	1.240	0.1444	1.640	1.180	0.0036 *
X20	−1.300	−1.430	0.2840	−1.210	−1.610	0.0006 *	−1.160	−1.540	−1.450	0.0066 *	−1.560	−1.340	0.1434
X21	−0.290	−0.520	0.0240 *	−0.230	−0.710	0.0000 *	−0.300	−0.530	−0.470	0.0678	−0.490	−0.430	0.6181
X22	−0.690	−0.940	0.0203 *	−0.610	−1.160	0.0000 *	−0.740	−0.940	−0.630	0.1176	−1.050	−0.800	0.0609
X23	−0.550	−0.550	1.0000	−0.550	−0.550	1.0000	−0.580	−0.550	−0.470	0.9002	−0.730	−0.510	0.0976
X24	−0.660	−0.750	0.3927	−0.610	−0.860	0.0137 *	−0.660	−0.770	−0.630	0.5656	−0.980	−0.660	0.0182 *
X25	−0.310	−0.310	1.0000	−0.310	−0.340	0.7381	−0.350	−0.310	−0.220	0.8210	−0.450	−0.280	0.1820
X26	0.450	0.570	0.2079	0.530	0.530	1.0000	0.560	0.500	0.530	0.8664	0.600	0.530	0.4956
X27	1.010	0.740	0.0078 *	0.730	1.010	0.0060 *	0.840	0.870	0.630	0.6278	1.310	0.760	0.0002 *
X28	1.140	1.200	0.5622	1.070	1.340	0.0096 *	1.080	1.260	1.010	0.1860	1.420	1.130	0.0524
X29	0.760	0.860	0.3310	0.870	0.760	0.2647	0.820	0.820	0.680	0.8655	0.820	0.820	1.0000
X30	−0.420	−0.210	0.0359 *	−0.250	−0.340	0.3388	−0.290	−0.290	−0.070	0.6223	−0.320	−0.290	0.7614
X31	−0.530	−0.390	0.1626	−0.490	−0.370	0.2029	−0.570	−0.380	−0.070	0.0489 *	−0.310	−0.470	0.2115
X32	−0.230	−0.130	0.3312	−0.140	−0.210	0.4887	−0.170	−0.170	−0.120	0.9759	−0.310	−0.140	0.1631
X33	−0.530	−0.440	0.3596	−0.410	−0.550	0.1607	−0.470	−0.470	−0.370	0.9113	−0.590	−0.440	0.2324
X34	0.520	0.550	0.7233	0.400	0.750	0.0004 *	0.520	0.550	0.940	0.3176	1.000	0.460	0.0001 *
X35	0.170	0.140	0.6889	0.110	0.190	0.3814	0.100	0.140	0.350	0.5710	0.250	0.120	0.3177
X36	0.460	0.210	0.0097 *	0.250	0.370	0.1790	0.400	0.260	−0.120	0.0756	0.490	0.260	0.0764
X37	0.890	0.780	0.2675	0.680	1.030	0.0004	0.950	0.740	0.570	0.0623	0.940	0.800	0.2802
X38	0.430	0.290	0.1460	0.240	0.480	0.0095 *	0.340	0.340	0.080	0.5418	0.500	0.310	0.1292
X39	0.980	0.850	0.2089	0.850	0.980	0.1940	1.100	0.790	0.450	0.0020 *	0.690	0.950	0.0438 *
X40	0.500	0.430	0.5064	0.420	0.500	0.3980	0.490	0.410	0.870	0.1976	0.500	0.460	0.7109

* means that *p*-value less than 0.05.

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