The framework for assessing public transportation by using competitiveness index indicators

G K Sinniah¹, X Y Li¹* and S Abdulkarim

Department of Urban and Regional Planning Faculty of Built Environment, Universiti Teknologi Malaysia, 81310 Skudai, Johor Bahru, Johor, Malaysia

E-mail: xiangyu@graduate.utm.my*

Abstract. Many institutes measured and published the competitiveness ranking, in various fields of study and research as well as in the urban planning and development processes. While the city transportation is one of the main components that always be assessed from different dimensions, however people prefer to focus on pre planning and construction by exploring and measuring the effectiveness level after completion. In this paper, we assess public transportation competitiveness in terms of the bus system based on a self-evaluation framework built from numerous measuring variables to identify the current situation in the study case city Johor Bahru, Malaysia. We comply with the PCA (Principle components analysis) to divide the evaluating indicators to three categories, and eventually use TOPSIS and Fuzzy algorithm to evaluate the bus system. The study found significant improvement compared with the previous study evaluation that the competitiveness class from Bronze to Silver ranking. Simultaneously, we gained an evaluating framework from infrastructure, available and perception aspect that could be used in other places. The result verified that it is necessary and meaningful to verify the performance of the public transit system after completion due to we could revise or optimize it immediately to reach the expecting.

1. Introduction

Not everybody can afford to own private transportation because of the cost involved when traveling from one place to another. By choosing a public transport mode, it is very cost-effective, safe, and easy to access. Besides, to the National Express Transit, busses will emit 20% less carbon monoxide than one private vehicle. The growing population and economic growth are vital for providing excellent public bus services to support the expansion of urban activities. Simultaneously, the definition of public transportation competitiveness is the ability to attract travellers to use public transportation compared to other competing travel modes under certain traffic conditions.

Malaysia is a federation comprising 13 states and three federal territories. Furthermore, among these, the infrastructure facility situation is slightly different; likewise, the people's attitude for public transportation is also different in extent. For instance, the public transportation contributed around 20% of Kuala Lumpur’s passenger movement people, whereas it is about 15% in Johor Bahru [1].

Johor Bahru located in the south of Malaysia as Figure 1 shows, and is one of the four major urban centres in Malaysia. It has been identified to have the potential to become competitive cities based on a study conducted by the Economic Planning Unit (EPU) with the World Bank in 2015. According to
the Johor Public Transport Masterplan (2015), the Johor Bahru District population was 1,003,000 (Department of Statistics Malaysia, 2015) and expected to have a population of 4,715,587 by 2045. The local authority devotes create public transportation to relieve the serious urban traffic stress [17].

![Figure 1. Johor Bahru District Map](source: Johor Bahru Transport Masterplan (2015-2045)[17]

2. Problem Statement

Customer satisfaction in public transportation is vital to recognize and analyze passengers' expectations and demands [2]. It is also significant for the supplier to build and improve this system to reach the desired result. Under these backgrounds, some institutes establish a holistic evaluation system to compare the central city worldwide or in a specific realm to reveal the urban living situation or city's sustainable developing depth.

Such as the World Economic Forum published "The Global Competitiveness Report 2017–2018" that devote identify the main challenges and barriers to growth facing their economies to make economies more competitive, productive, and prosperous. The urban transport competitive ranking also formed due to the rapid urbanization in which the urbanized population in the world would increase from 55% (2015) to 68% (2050).

In Malaysia, urbanized population would rise from 75% in 2015 to 90% in 2050 (Data from the United Nations "The Prospect of World Urbanization"). Moreover, urban transport not only relieves the traffic stress because of mass transit capacity but also reduces per unit consumption of energy that benefits the natural environment and human health. According to the estimation of 'Low Carbon Society Blueprint for Iskandar Malaysia, 2025' [3], the auto ownership is expected to grow from 500 cars per 1000 people to more than 800 cars per 1000 people by 2025 because of the lack of adequate public transportation that leads to the growth of motor vehicles.

However, there is less emphasis on the public transportation factors that influence the city ranking in many competitive index reports, especially in Malaysia's realm. Malaysia is a famous tourist resort globally, thereby scholars usually research this aspect. Such as the author identified and assessed the tourist destination competitiveness by questionnaire to enable the industry stakeholders to manage and maintain the destination tourism resources more effectively [4].

Besides, a group is researching the overall urban transport in Malaysia from several aspects to reflect and summarize the realistic situation. Moreover, given some suggestions such as public transportation could reduce the emission of CO2 and a good organized, the planned strategy could solve the travel distance and congestion and less fuel consumption [5]. Indeed, no single index can answer all questions, and there is a need for multiple indicators.

Thereby, in terms of the urban public transportation field, several dimensions should be aimed and applied to measure and acknowledge the exact situation. For instance, to assess Urban public
transportation competitiveness in Qinhuangdao City, where located northeast of China, used fourteen indexes from public transportation infrastructure and service quality to reflect local public transportation situation [5]. Besides, the author [6] adopted fifteen indexes from three visions to evaluate sustainable transportation in Taipei, China. By this limited that many people focus on metropolis or capital city, whereas the rest city also significant to be identified.

Changing focus to the Johor Bahru as a testing sample, according to previous evaluating that Johor Bahru scored a 50% or Bronze rating in Public Transportation Indicator. It estimated the public transportation performance according to accessibility, fare and payment, information technology and service performance these four variables, and the Bronze rating means “Rarely acceptable with major improvement of public transportation services to support competitiveness city”.

Is there has any tangible improvement after the local government implemented some measures to improve urban public transport? Thereby identify currently public transportation performance and endeavour to form competitiveness evaluating, it is significant, whereas the forecasting would be true which the public transport usage to decline from 15% to 10% by 2030 [1]. And it will remarkably increase urban traffic pressure compare with the current.

3. Literature Review

3.1. Global Index on Transportation

Competitiveness cities involve a very comprehensive concept and consider components such as commercial, institution, liveable city, green technology, transportation, and urban governance. As [7] mentioned, transportation is a crucial part of our daily lives and is undergoing significant transformation globally. They built 23 indicators to reflect a component of urban mobility from infrastructure expenditure commitment to public transportation affordability, thereby assessed 100 cities around the world.

Also, many people build different evaluation index system to reflect researching area situation. Such as [8] built four dimensions to assess the public transportation competitiveness, and “fuzzy QFD” in order to translate the passenger demand into service quality specification adopted eight criteria to survey customer satisfaction. While according to these researching achievements, the commonality and heterogeneity gradually emerge that the evaluation indicator quantity is not small. Perhaps there is no uniform standard to assess the social phenomenon, whether for holistic city performance or one aspect of society. Everyone merely adopted suitable criteria to build an evaluation system to identify and determine the realistic status of interesting matter.

3.2. Indicators selection

As below Table 1 shows, people identify the competitiveness whether the urban transport or tourist field from various aspects by the different method. Moreover, the indicator selecting should follow the study area characteristic due to the discrepancy in the choosing place. Thereby, by the global indexes, the study will cover the following indicators suitable for evaluating public transportation in the Johor Bahru area because it is our sample area. This evaluation system is combined under five aspects: affordability, service performance, safety, infrastructure and investment.
### Table 1. The reference about the competitiveness evaluating of the urban realm

| Reference                  | Aim                                                                 | Measuring indicator                                                                 | Methodology                                      | Case study            | Result                                                                                                |
|----------------------------|----------------------------------------------------------------------|-------------------------------------------------------------------------------------|--------------------------------------------------|-----------------------|--------------------------------------------------------------------------------------------------------|
| Sitao HU, Chuchu DAI, 2012 | assess Urban public transportation competitiveness                     | public transit infrastructure and service quality of public transit                   | AHP (Analytic hierarchy process)                  | Qinhuangdao, China    | can meet the travel needs of residents, but the network structure is below the level                 |
| Shiau, Tzay An, 2012       | evaluating and prioritizing transport sustainability strategies       | land use planning, shifting model, using clean energy                               | Sustainability compound index (SCI) assessment, AHP (Analytic hierarchy process) | Taipei                | top five strategies should be mentioned such as improving transport accessibility for elderly and disabled persons etc. |
| Deveci et al. 2019         | assess public bus operators based on the passenger demands            | Frequency, Convenience, Driver behavior, Cleanliness and ergonomics etc.             | Principal Component Analysis (PCA), Quality Function Deployment (QFD), fuzzy (IVIF) approach | Istanbul              | cleanliness and ergonomics, reduced waiting time and travel time are the most mentioned by the customer |
| Sun, Hui, 2010             | built a competitive evaluation index system for urban public transport, and analyze the its competitiveness | production factors, demand conditions, related and supporting industries and competitiveness of public transport enterprises | TOPSIS (Technique for Order Preference by Similarity to Solution) | Hebei province, China | there exists obvious differences between each city’s public transport development level in Hebei, and the public transport development is quite unbalanced in Hebei. |
| Philip P. W. Wong, 2017    | evaluate the competitiveness of tourist destination in Malaysia       | Core resources and attractors, Supporting factors and resources, Destination management, Qualifying and amplifying determinants | regression analysis                              | Malaysia              | not all competitiveness attributes are equal in importance, and there is a discrepancy in the different destination |
| Zakaria, 2015              | estimated the public transportation performance in Johor Bahru         | accessibility, fare and payment, information technology and service performance       | PTCCI model (Public Transportation Competitiveness City Index) | Johor Bahru, Malaysia | Rarely acceptable with major improvement of public transportation services to support competitiveness city |
3.2.1. Affordability. According to [9], the social case of public transport subsidies recognized the importance of accessible, available, and affordable transport for the people. Most studies on poverty and public transport estimated the percentage of monthly income which spent in public transports, Armstrong-Wright and Thiriez (1987) considers there is an affordability problem with public transport when more than 10% of households spend more than 15% of their income, and to solve this problem, decision-makers must focus on the policies and infrastructure for alternatives modes (walking and cycling) and improve access to public transport and spend the subsidies in policies and infrastructure rather than fares.

3.2.2. Service Performance. Service performance is the evaluation of actual service received by customers to determine the quality of service they have. Customer evaluation often depends on performance so that it can explain variance in measuring service quality as a whole. These techniques allow the critical aspects of the supplied services to be identified and customer satisfaction to be increased [10]. The dimension of measuring service performance among them are tangibility, reliability, providing service as promised, Etc.

3.2.3. Safety. There is a hierarchy in the quality of public transport, which consists of different class security is identified as a degree of safety from 3 aspects: Safety from crime/ Safety from accidents/ Perceptions of security. The impact of bus systems on road safety is particularly significant because they tend to be situated along major urban arterials. Furthermore, the author [11] and [12] created 23 variables to measure the correlation between city-level and traffic safety of 100 major urban areas in the United States. It shows that improving transportation networks, facilities, and infrastructure can indirectly decrease traffic facilities by encouraging non-driving transport modes. Remarkably, public transport safety performance could not be ignored, whatever for the city or itself.

3.2.4 Accessibility. According to [13], accessibility could be measured by the people’s ability to reach goods, services, activities, or affected destinations. Many factors affect accessibility, such as mobility, quality, and affordability of transport modes, system, connectivity, and land use pattern. They describe two views for accessibility, from the origin (reachable activities), and the destination or catchment area [14]. These perspectives are related to the demand and supply side.

3.2.5. Public transport infrastructure. Of interest to this study, the author [15] put the infrastructure into two main types. Firstly, the hard infrastructure and secondly is soft infrastructure. Hard infrastructure is classified under the capital assets, while the soft infrastructure includes the framework to keep and maintain the different institutes. The soft infrastructure incorporates the system of delivery of services to the people. Moreover, lots of evidence verified that the hard infrastructure and soft infrastructure complement each other, which means the public transportation infrastructure would not be reasonable when lacking hard infrastructure or soft infrastructure.

3.2.6. Investment. Public transport requires numerous investments based on the technique used and the population density [16]. While there are no standard guidelines on how much a government should spend on public transport. Generally, a good public transport allocation, would be around 5% from their yearly budget. Moreover, the term 'investing" could be associated with the different activities, the expected target in these activities is to "employ" the money (funds) during the period seeking to enhance the investor's wealth. Whereas, in the public transportation field, it guarantees inhabitants' well-being, ensuring the public transport system building and operating normally.

4. Methodology
As above mentioned, there are many methods could be used in recognizing the competitiveness of the urban field, and we reply two stages to do that. Initially, we estimate the correlation among the index, then reply PCA (Principle Components Analysis) to classify the index based on the selecting indicator
category, finally assess the indicator and obtain holistic evaluating result of the competitiveness by TOPSIS and fuzzy algorithm.

Johor Bahru has a few modes of public transport such as bus, train, and taxi. However, the most available public transport is the bus; others are considered when the bus is not available for similar trips by most public transport users in Johor Bahru [18]. In 2015, there were 11 bus operators serving throughout the cities. Due to the COVID-19 impacting, we adopted an internet survey to obtain evaluating data. The questionnaire quantity has been not less than 97 because the population in Johor Bahru is 1,003,000 and we hypothesis the most appropriate margin error of 10%. Meanwhile, the confidence level is the amount of uncertainty that can be tolerated is 95%. Finally, we gained 130 respondents by an internet survey.

4.1. To estimate the correlation among the index
To assess the competitiveness of the urban transportation that we should choose the reasonable and suitable variable based on study area characteristic. While the Pearson Correlation Coefficient Analysis is common means to do that to quantitative the inner correlation. The unit interval [-1,1] which -1 means there is a negative correlation between measuring index, vice the 1 means is positive, and if the value is 0 that means there is no correlation. And the correlation degree gradually weakens from -1 to 0 as well as 1 to 0.

4.2. To classify the index
As previous showing that we select five indicators to evaluate the urban public transportation competitiveness. While these variables have some potentially or directly correlation. Thereby we attempt using PCA (Principle components analysis) to classify it into different category. PCA is a commonly method when filtering the indicator to gain the dimensionality reduction. Meanwhile, it measures the loadings to classify it into different factor.

4.3. Assess the urban public transportation competitiveness
After that, to assess each indicator’s performance, we adopt TOPSIS (Technique for Order Preference by Similarity to an Ideal Solution) a multi-criteria decision analysis method. It is a compensatory aggregation method that compares a set of alternatives by identifying weights for each criterion, normalizing scores for each criterion, and calculating the geometric distance between each alternative and the ideal alternative, which is the best score in each criterion. Moreover, the unit interval is [0,1], and the 1 means the best solution, vice the 0 means the worst solution. Besides, to obtain the holistic evaluation status of competitiveness, we use Fuzzy logic, a form of many-valued logic that truth values of variables may be any real number between unit interval [0,1], both inclusive. Furthermore, the ranking from 1 to 0 which 1 is the top and 0 is the last. The specific stage as follow shows:

4.3.1 Establishment of weighting values between indicators. 1) Normalization for all indicators: Hypothesis there are n independence indicators for evaluating public transportation performance. There is a need to normalize all indicators into dimensionless for effective comparison. 2) Weighting values for all individual indicators: Based on the real situation, our indicator is selected from other articles as above mentioned, therefore, it could be considered the weighting value is the same among different questions. Meanwhile, different factors have different quantity numerical questions, thus, to assess it, we could add it to get factor weighting value.

4.3.2 Analysis of the values of indicators. 1) Indicator influence level: Calculate the weighted normalized decision matrix

\[ r_{ij} = \frac{x_{ij} - \text{Min}(x_{ij})}{\text{Max}(x_{ij}) - \text{Min}(x_{ij})} \]

\[ y_{ij} = r_{ij} \times w_{ij} \] \hspace{1cm} (1)
2) Calculate how close each evaluation object is to the best plan and the worst plan

\[ D^+_i = \sqrt{\sum_{j=1}^{m} w_i (y^*_j - y_{ij})^2}, \quad D^-_i = \sqrt{\sum_{j=1}^{m} w_i (y^-_j - y_{ij})^2} \]  

(2)

Where: how close each evaluation object is to the best (left) or worst (right) plan

3) Calculate the similarity to the worst condition

\[ C_i = \frac{D^-_i}{D^+_i + D^-_i} \]

(3)

Where: =1 if and only if the alternative solution has the best condition; and=0 if and only if the alternative solution has the worst condition.

4) Holistic level evaluation: Build the matrix depending on the questionnaire and normalize.

\[ R = \begin{bmatrix} r_{11} & \cdots & r_{1n} \\ r_{21} & \cdots & r_{2n} \\ \vdots & \ddots & \vdots \\ r_{m1} & \cdots & r_{mn} \end{bmatrix} = \left( r_{ij} \right)_{m \times n}, \quad \sum_{j=1}^{n} r_{ij} = 1 \]

(4)

Where: \( r_{ij} \) calculate is (1) equation

According to Fuzzy evaluation, the algorithm is Zadeh, as follow:

\( \forall a, b \in [0,1], \text{ Zadeh algorithm is } (\lor) \text{ and } (\land), \quad a \lor b \equiv \max(a, b), \quad a \land b \equiv \min(a, b) \)

The holistic level evaluation algorithm as follow:

\[ B = A^o R \]

(5)

Where: is five evaluation level of indicator constitute as “Gold, Silver, Bronze, Basic, Entry”, and the “\( o \)” means fuzzy matrix algorithm “Zadeh”

Normalize B and the highest value means the evaluation result that match correspondence standard.

4.3.3. Ranking the estimating result. For this assessment of public transportation competitiveness ranking, we are using BRT standards (2016) [19] developed by the Institute for Transportation and Development Policy with some modification to determine the rank and measure the performance of public transportation competitiveness (Table 2). It keeps consistent with last time that another one did it in 2015 that we use the same ranking index in order to tangibly see the changing comparing with last time whether is better or inverse.
Table 2. Evaluating standard modification based on Institute for Transportation and Development Policy

| Standard | Description |
|----------|-------------|
| **Gold** | Point and above is consistent in almost all respects with international best practice. This indicator is the highest level of operational performance and efficiency for providing high quality services. |
| **Silver** | Point and above includes most of the elements of best practice and likely to be cost effective with sufficient demand. These indicators achieve high operational and quality service. |
| **Bronze** | Point and above Bronze meet the definition of basic requirement public transport and consistency. These indicators have some characteristics that elevate above the Basic BRT requirement of public transportation. Some major improvement to support competitive cities. |
| **Base** | Point and above means the limited service of public transportation. |
| **Entry** | Point and above means merely has public transportation in somewhere and just can be used whereas there is no service performance can be said. |

Source: Adaptation of Bus Rapid Transit Standard (2016)

5. Findings and Discussion

5.1. Data analysis

In conclusion, the highest respondent in this research studies are in the age group 26-40 years with 26.15%, and the second-highest age group is 18-25 years old. From a total of 130 respondents, more than half of the respondents consist of females with 56.2%, and 43.8% are male. While most of the respondents who answer this questionnaire are employed with the total number of respondents, 69 respondents represent 53.1%, the second-highest group with a total percentage of 36.2%, or 47 respondents are students. In terms of household income (monthly), most respondents have an income of RM1001 to RM2500 per month, representing the total percentage of 45.4%, which equals 59 respondents. Following this is income below RM1000, with the total percentage of 28.5% with the total number of 37 respondents due to the second majority of the respondent is a student, so their monthly income is not consistent and not higher than RM1000.

Initially, we measured the index correlation by Pearson Correlation Coefficient Analysis to identify the inner relation among whole measuring variables which verify the selecting indicator is about this survey topic. Moreover, the result as follow Figure 1 shows:
According to Figure 2 above, the significant feature could be recognized that the whole index positively correlates due to the Pearson Correlation Coefficient is bigger than zero. That means very indicators what we chosen are remarkable impacting with the public transportation, while the influence degree is different.

Based on this, in order to assess the public transportation from different aspect that we divided these twelve indexes into three categories by PCA (Principle components analysis), that distinguishing the indicator's inner correlation [20]. The outcome shows below Figure 3:

These twelve indexes have been classified into three categories as the Figure 4 shows. And the correlation degree between the index and the indicator shows as the left figure, that the value higher means the correlation higher compare with other indexes what belong to the same category. Furthermore, the explanation ability as below Figure 5 shows that the Infrastructure indicator (RC1) could interpret 45% about the public transportation competitiveness as for the Proportion Explained is 0.45, which same with normal understanding due to the public transport infrastructure is the most important in this system. The Available indicator (RC2) and Perception indicator (RC3) almost same in explaining the public transport competitiveness aspect that the proportion is 28% and 27% respectively.
Furthermore, urban infrastructure is vital for raising the overall quality of life and driving sustainable urban development, both socially and economically [21]. In terms of urban public transport, it is also significant that many urban regions enhance or consider improvements to public transportation infrastructure to address the private vehicle use challenge [22].

Our survey result shows that the public transportation infrastructure perspective obtains the most significant proportion in the whole evaluating system with 45%, the rest part Available and Perception is 28% and 27% respectively that as to the PCA calculating result. While, for the per index that we deem the weighting value is same due to all of these are positively correlation as the Pearson Correlation Coefficient Analysis measured.

Thereby, the per index measuring result as follow Table 3 shows, the best one in the evaluating framework is the Bus Fare due to its Ci value is the highest (0.72), and the following is Safa Environment in the coach because it gains 0.67 of the Ci. While the last one is Real-time information which obtains 0.56. Actually, the all of the selecting index performance Ci value is more than 0.5 as to the unit interval is [0, 1] as for this result represents not very bad, which the 0 and 1 mean the worst condition and best condition respectively.

Table 3. The variable assessing result

| Index   | D+     | D-    | Ci       |
|---------|--------|-------|----------|
| BusF    | 0.08355| 0.215921| 0.721008 |
| safeE   | 0.099369| 0.203503| 0.71912  |
| safeS   | 0.102592| 0.202255| 0.663463 |
| distance| 0.107077| 0.203147| 0.654839 |
| travel  | 0.105031| 0.197734| 0.653094 |
| peakH   | 0.107415| 0.194599| 0.64339 |
| network | 0.112191| 0.200909| 0.641677 |
| frequency| 0.11395| 0.195341| 0.631577 |
| security| 0.12222| 0.191414| 0.610309 |
| infor   | 0.127152| 0.188558| 0.597251 |
| disableF| 0.128284| 0.187789| 0.594131 |
| Rtinfor | 0.136878| 0.177389| 0.564454 |

where: disable; F=facilities for disabled; frequency= bus operating frequency; distance= bus station location, infor= bus schedule notice, safeE= safe environment in bus coach, safeS= safety of bus station, security=security system of transport system, network=public transportation network coverage ratio, peakH= supply ability during peak-hour, travel= travel journey, Rtinfor= real-time information, BusF= Bus fare.

Moreover, according to the Fuzzy algorithm, we evaluated the public transportation competitiveness as below Table 4 representing:
Table 4. The holistic assessment result of public transportation competitiveness

| Category      | Weighting | Bad          | Basic        | Bronze       | Silver       | Gold         |
|---------------|-----------|--------------|--------------|--------------|--------------|--------------|
|               |           | StrONGLY DISAGREE | DISAGREE | NORMAL | AGREE | STRONGLY AGREE |
| Infrastructure|           | disableF 45.00% | 3.85% | 10.44% | 19.56% | 47.03% | 19.12% |
|               |           | frequency   |            |            |            |             |            |
|               |           | distance    |            |            |            |             |            |
|               |           | infor       |            |            |            |             |            |
|               |           | safeE       |            |            |            |             |            |
|               |           | safeS       |            |            |            |             |            |
|               |           | security    |            |            |            |             |            |
| Accessibility|           | network 28.00% | 2.69% | 9.62% | 19.23% | 50.00% | 18.46% |
|               |           | peakH       |            |            |            |             |            |
| Perception    |           | travel 27.00% | 3.33% | 9.23% | 18.21% | 51.28% | 17.95% |
|               |           | RtinfoF     |            |            |            |             |            |
|               |           | BusF        |            |            |            |             |            |
| B             |           | 0.0385      | 0.1044     | 0.1956     | 0.4500      | 0.1912      |

It shows the public transportation in the Johor Bahru obtained Silver in this survey because this item gained the highest value compared with others, which our question is “Do you agree the public transportation in Johor Bahru is good?”. Moreover, match it into the evaluating standard that means “Point and above includes most of the elements of best practice and likely to be cost effective with sufficient demand. These indicators achieve high operational and quality service”.

5.2. Finding discussion

Our survey result shows that the public transportation infrastructure perspective obtains the most significant proportion in the whole evaluating system with 58.31%. Moreover, the respondent deemed this aspect is not bad because it obtained 47.03%, which means almost half of people agree it is good, and gain "silver" matching the evaluating standard. Besides, in this part, the safe environment and safe bus station obtained first and second grading that is 0.6719 and 0.6635, respectively, while the security facility aspect only has 0.6103. That could not be ignored because the security facility performance would be determined by IoT (Internet of Things) in extent.

This result could remarkably acknowledge the IoT facility is lagging, as to the appraisal of security facility, information notice, and real-time information system are not very good. Meantime, the disabled facility should be mentioned due to it only gets 0.5941, which means it is not bad or good following the evaluating range between 0 to 1, but it is ranked penultimate in the holistic evaluating framework.

Indeed, to reduce the of using automobility, supplied transit service must be available to as many users as possible [22]. Our evaluating framework is reflected by public transportation network coverage ratio and supply ability during peak-hour. Furthermore, in this part, 50% of people consider it good to obtain "silver" assessment, which the network grading is 0.6417, and the peak-hour performance is 0.6443. That meaning the bus network coverage ratio and peak-hour capacity enough most of the rider expectation.

To recognize it tangibly, we collected other data about bus service network situations, as the below Figure 6 shows. We hypothesize the bus station coverage range is 400 meters which the bus coverage ratio is 51.48%, and the method is total the bus station coverage area divided the construction area in
Johor Bahru. Then, we put it into the standard of “Transit Capacity and Quality of Service Manual” (United States), this coverage ratio means “bus service covers the most area in the high-density community, but the first or last mile is far and difficult to handle whether by walking and cycling”. It differs slightly from the respondent's feedback.

![Bus station coverage range (400 meters)](image)

**Figure 6.** Bus station coverage range within 400 meters

Although the respondent deems the network coverage ratio reasonable, it also displays that accessibility should be enhanced by improving the public transportation network and increasing availability, which merely has 49 (46.7%) and 50 (47.6%) responders. Therefore, increasing bus line and bus service in the uncovered area is significant for the potential rider. It would give a positive impression hence attract more people using it to reach the goal for the supply side.

Attracting more people away from private vehicles and using public transportation is not easy. People always calculate the expenditure, mind the user experience, Etc. whatever for public transport or other things which want to obtain people mention. Wherefore, customer perception also should be cared for when assessing public transportation competitiveness.

Indeed, the perception includes subjective and objective two aspects. Our survey applied one subjective (travel journey satisfaction) and two objective indexes (real-time information and bus fare) to evaluate it. In this aspect, it gains the most considerable grading, in which 51.28% of people deemed it suitable, and the evaluating standard is "silver". Although the real-time information (0.5645) is the lowest in the whole indicator, the bus fare index (0.721) obtains the highest among it. Directly reflect the bus fare policy is successful because the resident only needs RM 10 to register the smart card and take some bus line free during the next one-year period.

However, it also clearly shows people mind the real-information system of the bus. Therefore, the agency company or department should invest more finance in the bus operating soft infrastructure to improve the public transportation infrastructure and the rider's perspective for the public transportation system.

6. **Conclusion and Recommendation**
Based on these studies, this paper found that Johor Bahru public transportation achieves absolute improvements compared with previous assessing. This study found out that Johor Bahru's public
transportation competitive index is rated as Silver Rated, which means most of travel demand in term of public transportation could be meet by currently system. However, there still are something should be mentioned and improved to achieve the goal that reduce the private mode’s share in trip marking from 75% (2005) to 35% (2035) and increase the public mode’s share from 15% (2005) to 40% (28% bus, 12% rail2025) [3].

6.1. Enhance the public transportation network
As above showed the bus station coverage ratio only has 51.84% if hypothesis the station covering range is 400 meters. That standard means the bus service only meet the high-density community and the first-last mile could not be solved. And it has been represented by the questionnaire survey which the respondent considered the bus availability is a shortage. While, to solve this issue that the bus operating agency could build more bus line in the vacant place as well as building the bus station. Due to the people walking willing barely has around 400-800 meters in Malaysia [23]. Thereby, it is useful to attract people from automobility to public transportation when the availability has been enhanced.

6.2. Improve the information system of the bus
The survey result shows the real-information and bus schedule notice item gain first and third from last respectively in all of assessing index. That means the people very caring about it due to them can arrange their schedule if there is reliable real-information of the bus operating. While to achieve this purpose that could improve the IoT (Internet of Things) that people could know the bus specifically operating situation in the bus station or in their smartphone. Meantime, the IoT also could optimize the security of the bus system as well as the safety of the bus station. That could significantly enhance the public transportation system from several aspects by cost-efficient means.

6.3. Reinforce publicity
Actually, to increase the public share that local authority released the discount card which people only need spend RM 10 (Adult) or RM 5 (Child & Older) to register it and could take the bus free in one year. However, only are 48(36.9%) responders done that. It clearly shows that there's a significant lack of awareness among the respondents with this initiative that has been introduced by the bus operator. Hence, the operating company and the department could publicity it via various media outlets including but not limited Facebook, Instagram and radio as well as notice it in the bus station noticeboard. Indeed, we not saw any publicity in the bus station when we waiting the bus. As for this public transportation assessing framework, we gained some effective and meaningful outcome in the case area that could help us to identify the current public transportation competitiveness and compare the achievement after this system improving project has been implemented that done it in 2015. However, this primary evaluation focuses on survey data that perhaps has some deviation because sampling selection is holistic, and the responder is probably living an excellent bus service community. Therefore, there also are some issues with it. Hence, the evaluation of this could adopt multidimensional data to enhance result accuracy and get more objectively result.

References
[1] Zaman M, Sultan Z, Fard M, Siyaka A, Pung JC. An Assessment of Public Transport Facility in Johor Bahru: a case study in Taman Ungku Tun Aminah Area, Majlis Perbandaran Johor Bahru Tengah, Malaysia. International Journal of Built Environment and Sustainability 2017;4:71–80. https://doi.org/10.11113/ijbes.v4.n2.178.
[2] Wong PPW. Competitiveness of Malaysian destinations and its influence on destination loyalty. Anatolia 2017;28:250–62. https://doi.org/10.1080/13032917.2017.1315825.
[3] Centre U-LCAR. Low Carbon Society Blueprint for Iskandar Malaysia 2025 - Summary for Policymakers. vol. 53. 2013. https://doi.org/10.1017/CBO9781107415324.004.
[4] Almselati ASI, Rahmat RAOK, Jaafar O. An overview of urban transport in Malaysia. *Social Sciences* 2011;6:24–33. https://doi.org/10.3923/sscience.2011.24.33.

[5] Sitao HU, Chu chu DAI and SC. Urban Public Transport Competitiveness Evaluation Based on AHP and Extension Theory 2012:2433–42. https://doi.org/10.1061/9780784412442.071.

[6] Tzay An S. Evaluating sustainable transport strategies with incomplete information for Taipei City. *Transportation Research Part D: Transport and Environment* 2012;17:427–32. https://doi.org/10.1016/j.trd.2012.05.002.

[7] Sun H, Fan Z, Shi Y. Research on comprehensive evaluation of urban public transport competitiveness in hebei province based on TOPSIS. 2010 *International Conference on Logistics Systems and Intelligent Management, ICLSIM 2010* 2010;1:250–4. https://doi.org/10.1109/ICLSIM.2010.5461426.

[8] Deveci M, Öner SC, Canttez F, Öner M. Evaluation of service quality in public bus transportation using interval-valued intuitionistic fuzzy QFD methodology. *Research in Transportation Business and Management* 2019;33:100387. https://doi.org/10.1016/j.rtbm.2019.100387.

[9] Serebrisky T, Gómez-Lobo A, Estupiñán N, Muñoz-Raskin R. Affordability and subsidies in public urban transport: What do we mean, what can be done? *Transport Reviews* 2009;29:715–39. https://doi.org/10.1080/01441640902786415.

[10] Vergel-Tovar CE, Rodríguez DA. The ridership performance of the built environment for BRT systems: Evidence from Latin America. *Journal of Transport Geography* 2018;73:172–84. https://doi.org/10.1016/j.jtrangeo.2018.06.018.

[11] Najaf P, Thill JC, Zhang W, Fields MG. City-level urban form and traffic safety: A structural equation modeling analysis of direct and indirect effects. *Journal of Transport Geography* 2018;69:257–70. https://doi.org/10.1016/j.jtrangeo.2018.05.003.

[12] Laaly S. New definition of Transit Oriented Development (TOD) based on context sensitive paradigm. *ProQuest Dissertations and Theses* 2014:171.

[13] van Maarseveen M, Martinez J, Flacke J, Singh YJ, Flacke J, Zuidgeest M, et al. Planning for Transit Oriented Development (TOD) Using a TOD Index. *GIS in Sustainable Urban Planning and Management* 2019:267–82. https://doi.org/10.1201/9781315146638-15.

[14] Skorobogatova O, Kuzmina-Merlino I. Transport Infrastructure Development Performance. *Procedia Engineering* 2017;178:319–29. https://doi.org/10.1016/j.proeng.2017.01.056.

[15] Boujbelene Y, Derbel A. The Performance Analysis of Public Transport Operators in Tunisia Using AHP Method. *Procedia Computer Science* 2015;73:498–508. https://doi.org/10.1016/j.procs.2015.12.039.

[16] FANG W. Comparison and Application of Principal Component Analysis & Factory Analysis 2003:6–8. https://doi.org/10.16309/j.cnki.issn.1007-1776.2003.03.004.

[17] Johor PPA. Johor Bahru Transport Masterplan(2015-2045). vol. 53. 2016.

[18] Moghaddasi A. Transport Cost Analysis of City Bus and Private Car Usage in Johor Bahru , *Journal Teknologi* 2013;3:25–31.

[19] Institute for Transportation & Development Policy (ITDP). the Bt Standard Introduction Bt Awards Showcase Scoring in Detail Application To. *The BRT Standard* 2016.

[20] Chen Y, Shen L, Zhang Y, Li H, Ren Y. Sustainability based perspective on the utilization efficiency of urban infrastructure — A China study. *Habitat International* 2019;93:102050. https://doi.org/10.1016/j.habitatint.2019.102050.

[21] Chakour V, Eluru N. Examining the influence of stop level infrastructure and built environment on bus ridership in Montreal. *Journal of Transport Geography* 2016;51:205–17. https://doi.org/10.1016/j.jtrangeo.2016.01.007.

[22] Eboli L, Forciniti C, Mazzulla G. Service Coverage Factors Affecting Bus Transit System Availability. *Procedia - Social and Behavioral Sciences* 2014;111:984–93. https://doi.org/10.1016/j.sbspro.2014.01.133.
[23] Azmi DI, Karim HA, Amin MZM. Comparing the Walking Behaviour between Urban and Rural Residents. Procedia - Social and Behavioral Sciences 2012;68:406–16. https://doi.org/10.1016/j.sbspro.2012.12.237.