Nigerian Journal of Technology (NIJOTECH)
Vol. 42, No. 4, December, 2023, pp.437 - 446
www.nijotech.com

Print ISSN: 0331-8443
Electronic ISSN: 2467-8821
https://doi.org/10.4314/njt.v42i4.3

DEVELOPMENT OF PASSENGER'S WAITING TIME MODEL AT BUS PUBLIC TRANSIT TERMINAL

AUTHORS:
M. N. Ibrahim[1,*], and J. K. Ede[2]

AFFILIATIONS:
[1,2]Department of Civil Engineering, Bayero University, Kano, Nigeria

***CORRESPONDING AUTHOR:**
Email: mnibrahim.civ@buk.edu.ng

ARTICLE HISTORY:
Received: 26 June, 2023.
Revised: 29 December, 2023.
Accepted: 30 December, 2023.
Published: 12 February, 2024.

KEYWORDS:
Bus, Public transit, Passengers, Waiting time, Terminal

ARTICLE INCLUDES:
Peer review

DATA AVAILABILITY:
On request from author(s)

EDITORS:
Chidozie Charles Nnaji

FUNDING:
None

Abstract

Passenger's waiting time at terminal is a key constituent of travel time, as long waiting time increases the overall journey time. In Nigeria, urban-rural bus transit system is associated with long waiting time. This study evaluates bus transit users' waiting times at terminal with perceived and actual waiting times (PWT and AWT) along with associated bus service frequency (BSF). Bus public transit operating from Enugu city (as origin) to 6 local government areas (Awgu, Isi-Uzo, Nkanu west, Nsukka, Oji River and Udenu) of the state as destinations was studied. Data were collected on AWT and PWT at Old Park, Enugu for 30 days from 8 am to 6 pm (5 days per route). Data on AWT and PWT were collected based on passenger's observation and oral interview, respectively. The study discovered that transit users incurred long waiting times, with 80 – 90% of the users incurring AWT of 21 minutes to 1 hour and more, indicating a poor service quality. Also, 80 – 90% of the users overestimated their PWT by 25 – 60%. At 95% confidence level, PWT is significantly longer than AWT ($P < 0.05$) for all the routes. A passenger's perceived waiting time model was developed for predicting PWT based on AWT. The model developed showed that PWT is strongly correlated with AWT, with an $R^2 = 0.9591$ and F-significance < 0.05. This suggests that that AWT accounts for 96% variability in PWT. Consequently, the model developed exhibits a reasonable accuracy, hence, can be applied for prediction of passenger's perceived waiting time. The mean BSF for Enugu – Nsukka and Enugu – Oji River routes were 30 and 21 buses per day, respectively. While, the other 4 routes recorded lower values of 7 – 9 buses per day, resulting in longer waiting times than the other 2 routes. The implication of long passengers' waiting time suggests the need for shifting from unscheduled to scheduled operation and improved BSF by shortening bus headways to minimize waiting time.

1.0 INTRODUCTION

Transportation being the movement of people and goods from one place to another, is expected to reasonably be safe, efficient, reliable and sustainable. The need for mobility is a necessity for humans as resources are naturally not concentrated in one place. One of the key functions of human settlement spatial structures is to facilitate the movement of people and goods within the settlement [1]. This makes transportation a derived-demand that is people do not just travel for travel's sake. Rather, they make trip in order to satisfy their desires relating to many aspects of life. Hence, each trip is therefore made for a particular purpose.

HOW TO CITE:
Ibrahim, M. N., and Ede, J. K."Development of Passenger's Waiting Time Model at Bus Public Transit Terminal", *Nigerian Journal of Technology*, 2023; 42(4), pp. 437 – 446; *https://doi.org/10.4314/njt.v42i4.3*

© 2023 by the author(s). This article is open access under the CC BY-NC-ND license

In Nigeria, road transport has been one of the means by which substantial proportion of the populace make their regular trips for varying purposes. Use of road public transport system constitutes a significant proportion of trips as it involves the movement of large number of people at once. The system plays a key role in productivity and national economies [2, 3]. The use bus of transit has been the common means of public transport in Nigeria for a long period. A common problem identified with public bus transit in Nigeria is long waiting time experienced by the users [4, 5]. Long waiting time experienced by passengers at bus terminal impacts on the transit time thereby increasing the users total travel time, because waiting time is a key constituent of passengers travel time [6]. In fact, it is deemed as an indicator for bus public transport quality of service [5, 7], as long waiting time at bus terminal is a good indicator of poor public transit service [8].

Generally, waiting for transit service is perceived negatively and more onerous than in-vehicle time by most public transit passengers [9 – 11]. Moreover, Wang, et al. [10] referred to the perception as a critical issue; since travel time is considered as one of the significant factors of trip makers when planning to travel. Earlier studies demonstrated that public transit users hate to wait at terminal [12, 13], particularly when weather condition is unfavourable [13]. Public transit users regarded waiting time as the most sensitive component of their travel time [14, 15]; such that a slight increase in expected waiting time could significantly cause discomfort to passengers, affecting the transit service reliability and its overall quality [16]. Eboli and Mazzulla [17] affirmed that service reliability with regard to waiting time is one of most significant service attribute for transit users and unreliable transit service lead to loss in passengers [18].

Other effects of longer waiting time at bus terminal is that it causes (and/or increases) discomfort and irritation levels to transit users [19], and increases their overall travel time with attendant delays [20]. These make waiting time an important element to both bus transit operators and users. Because, long waiting time at bus terminal increases passenger's overall journey time from origin to destination. Usually, transit users' total travel time consists of four elements. It includes time to arrive bus stop, waiting time for bus service, in-vehicle travel time and time to arrive at final destination from the bus stop [6, 10]. From the travel time components, the waiting time element appears to be the one where the transit users are more anxious and has little or no control over, rather than to simply wait for the departure time, perhaps, as deemed appropriate by the transit operators.

In Nigeria, bus transit service is associated with numerous problems, as in most cases the operation is unscheduled. One of the key problems identified with bus public transit in Nigeria is long waiting time at bus terminal [5]. Few earlier studies [2, 5, 21] on bus transit users' waiting times in Nigeria focused on intra-urban services, which mostly involves short to medium distance trip. However, there are limited or little studies on urban – rural bus transit, hence, there is limited information on users' waiting time on this. This reason motivated the need for the current study. The study explores and analyses waiting times experienced by bus transit users' departing from Enugu city (Old Park) to 6 local government areas (LGA) of the State. These are; Awgu, Isi-Uzo, Nkanu West, Nsukka, Oji River and Udenu LGAs.

For the fact that substantial public transport users in Nigeria travel by bus transit, it is essential to promote measures that could reduce user's waiting time. This would improve the operational performance or service quality of the bus transit system since waiting time at terminal is of utmost concern to the users [10]. This suggests that reducing transit users' waiting time is highly significance when planning and designing a public transit system so that the system can offer satisfactory service to customers. Hence, the current study attempts to assess bus public transit users' waiting times at terminal (from Enugu city to six local government areas of the State) and derived a relationship between the users' perceived and actual waiting times. Likewise, the study evaluates the bus service frequency of the transit system with a view to examine its influence on passengers' waiting at bus terminal. Findings from the study could be useful in appropriate design, planning and operation of bus public transit system or improvement of existing operational system with attendant benefits of enhanced service quality and user satisfaction.

1.1 Passenger's Waiting Time

Waiting time at bus terminal is the time interval spent at transit terminal between the moments of passenger's arrival and boarding the desired vehicle [22, 23]. Waiting at bus terminal is mostly perceived as a negative attribute by the transit users, with attendant negative effect on the overall assessment of the system's service quality [10]. With regard to bus transit system, Wang, et al. [10] described the waiting time in two forms; as Actual Waiting Time (AWT) and Perceived Waiting Time (PWT). The AWT can be

© 2023 by the author(s). Licensee NIJOTECH.
This article is open access under the CC BY-NC-ND license.
http://creativecommons.org/licenses/by-nc-nd/4.0/

objectively measured as the interval between transit users' arrival at the terminal and boarding the bus. On the other hand, PWT is a subjective variable, which heavily depends on psychological and environmental conditions experienced by the transit user at the bus terminal. Unlike AWT, PWT cannot be measured directly, however, it can be obtained by asking the transit users on how long they waited at the bus terminal.

Despite the significance of PWT for public transit improvement, the attribute is difficult to obtain with reasonable accuracy since users cannot precisely estimate the extent of their waiting time [24]. In most instances, the users overestimate the variable. Previously, studies established that transit users overestimate their waiting time at bus terminal; that is PWT is generally longer than AWT [6, 9, 10, 12, 25 – 28]. This situation is deemed unfavourable to both passengers and transit operators; and would in turn cause discomfort and dissatisfaction to the passengers. Overestimation of waiting time by passengers could be due to discomfort with the waiting environment, idleness while waiting, and anxiety to travel to meet up with planned or appointed schedules. Some earlier studies reported discrepancies between bus public transit passengers' perceived and actual waiting times [6, 10,16]; specifically, PWT being higher than AWT [6, 12, 29, 30]. Information on bus users' PWT is deemed as a key factor for bus public transit improvement [24]. Reduction of waiting time at terminal experienced by passengers was reported as one of the key approaches to improve users' satisfaction as well as bus public transport system [31, 32]. Hence, a study of this type is essential in order to assess the existing waiting times characteristics of bus transit users so as to provide counter measures to minimize the impact of long waiting time to the users.

2.0 METHODOLOGY

This study was conducted through a field data collection on bus public transit system relating to bus service frequency and passengers' waiting times characteristics. For passengers' waiting times at terminal, data were collected on users' actual waiting times (AWT) and perceived waiting times (PWT). Data for the respective variables were collected on daily basis from 8 am to 6 pm during week days for 5 days (Monday – Friday). The basis for the choice of week days for the data sampling in this study is that they seem to exhibit similar trip patterns.

Bus transit departing from Enugu city to 6 local government areas (LGA) of the state were used for the study. For the 6 LGAs used in this study, Enugu old park was used as the origin, while the LGAs were used as the respective destinations. The bus transit routes covered within the stated local governments are Enugu – Awgu, Enugu – Isi-Uzo, Enugu – Nkanu West, Enugu – Nsuka, Enugu – Oji River and Enugu – Udenu routes. The basis for the choice of the studied routes is that they seem to attract reasonable passengers due to their relative trip attraction land-uses (institutions, markets, other business and activities) and ease of accessibility.

2.1 Bus Service Frequency

Bus service frequency (BSF) is referred to as the total number of buses per day that arrive at the subject bus terminal with the intention of carrying passengers. To determine the BSF, the numbers of buses that take-off per day were observed and recorded at each terminal. Data on the BSF were also collected from 8 am to 6 pm for 5 days. The observed BSF for each day was always compared with the records made by the bus terminal managers in order to confirm the accuracy of the observation. The BSF information was generated in order to examine whether it influences the transit users' waiting times. It should be noted that the capacity of the bus category used in this study is 18 seats.

2.2 Measurement of Passenger's Waiting Time

Data on passengers' waiting times were collected for 5 days from 8 am – 6 pm. Data were collected on both actual waiting time (AWT) and perceived waiting time (PWT). The AWT was measured as the interval between transit users' arrival at the terminal and boarding through observation. While, the PWT was obtained by interviewing the transit users on how long they think they waited at the terminal. In other words, data on the AWT and PWT were collected through passenger's observation and oral interview, respectively.

To measure the AWT, passenger was randomly identified and his/her arrival time recorded. When passengers are called for boarding, the identified passenger's boarding time was recorded against his/her arrival time. The interval between the arrival and boarding time was recorded as the AWT. For the PWT, the same randomly selected passenger whose AWT was observed is approached and asked on how long he/she waited at the terminal before boarding (in minutes). The responses are noted as their PWT and recorded against their AWT. Though many AWT were recorded, only passengers who responded to the inquiry on PWT were included in the analysis. For all the 6 routes considered, 35 respondents were sampled per day for 5 days, making a total of 175 samples for

© 2023 by the author(s). Licensee NIJOTECH.
This article is open access under the CC BY-NC-ND license.
http://creativecommons.org/licenses/by-nc-nd/4.0/

each of AWT and PWT for each route. This makes a total of 1,050 sampled passengers for the 6 routes.

The data recorded on the AWT and PWT were then used to develop passenger's waiting time model. As stated earlier, unlike AWT, PWT is difficult to measure since its estimation relies on the passengers' perceptions. For this reason, a passenger's perceived waiting time model was developed for predicting the PWT based on ATW as described in Section 2.3.

2.3 Development of Passenger's Perceived Waiting Time (PWT) Model

To develop the passenger's perceived waiting time model, AWT and PWT were used as the input variables. In the modelling process, PWT was used as the dependent variable, while the AWT independent variable (predictor). Since PWT is difficult to estimate precisely, the aim of the model development is to allow for prediction of PWT based on easily measured AWT. A linear regression analysis method was used for the model development. Similar approach was previously used in other studies [6, 33] for modelling bus transit users' waiting time. The general form of the linear regression model is given by Equation 1.

$$y = \alpha_1 x_1 + \alpha_0 \quad (1)$$

Where, y is the dependent variable, α_0 is constant of regression, α_1 is coefficient of the independent variable x_1.

In terms of PWT and AWT, Equation 1 can be rewritten as in Equation 2.

$$PWT = \alpha_1 AWT + \alpha_0 \quad (2)$$

Where, PWT is the perceived waiting time and AWT is the actual waiting time. Developing the model, is basically to estimate the values of α_0 and α_1 (regression constant and coefficient), which can be used to predict PWT based on AWT. The regression analysis was performed using Microsoft Excel software at 95% confidence level (α = 0.05). Microsoft excel software has been widely applied for various statistical analyses and modelling by many researchers, and was found adequately efficient with satisfactory results that are well consistent with those of other software [10, 34 – 38].

3.0 RESULTS AND DISCUSSIONS

Results on bus service frequency (BSF), passengers' waiting times, and passenger's waiting time model development are presented and discussed herein. For the AWT and PWT, a total of 1,050 passengers waiting times (35 samples per day for 5 days for each of the 6 routes) were recorded for each of AWT and PWT.

3.1 Bus Service Frequency

The BSF data was generated in order to examine whether it influences the transit users' waiting times. Figure 1 shows the variation mean daily BSF for the 6 routes studied.

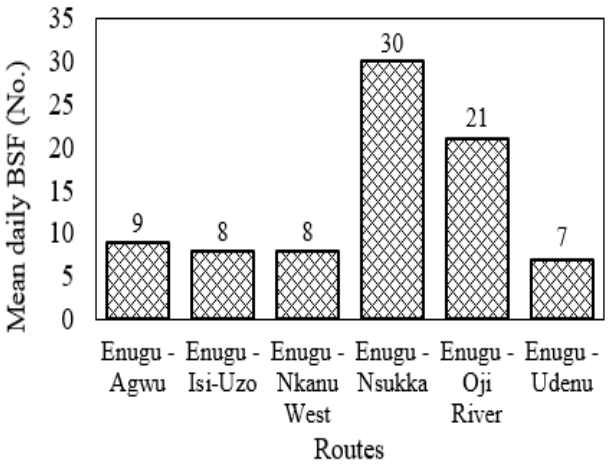

Figure 1: Variation of BSF for Studied Routes

From Figure 1, the mean daily BSF for 4 (Enugu – Awgu, Isi-Uzo, Nkanu West and Udenu) out of 6 routes ranges from 7 to 9 buses per day. While Nsukka and Oji River routes recorded 30 and 21 buses per day, respectively. Thus, the other 4 routes recorded considerably lower BSF compared to those Enugu – Nsukka and Oji River. The higher values recorded by the Enugu – Nsukka and Enugu – Oji River routes might be due their higher level of trip attraction land-uses, such as educational institutions, markets and other business activities. Their higher mean BSF might be the responsible factor for the lower waiting times incurred by the users on the 2 routes. Because, reduction of bus headway or increase in BSF reduces bus transit users' waiting time at terminal [39].

3.2 Passenger's Waiting Time

The actual waiting time (AWT) was estimated as the time interval between passenger's arrival at the terminal and boarding via observation. While, the perceived waiting time (PWT) was obtained based on passenger's perception through an oral interview.

Generally, regardless of type of waiting time; the study discovered that majority of the transit user experienced long waiting times at the terminal. For all the routes studied, 80 – 90% of the passengers experienced an AWT ranging from 21 minutes to 1 hour and more (up to around 100 minutes), with only about 10 – 20% who experienced AWT lower than 20

© 2023 by the author(s). Licensee NIJOTECH.
This article is open access under the CC BY-NC-ND license.
http://creativecommons.org/licenses/by-nc-nd/4.0/

minutes. Similar trends were recorded for the passenger's PWT. This shows that substantial proportion of the bus transit users experienced long waiting times. This imply an unsatisfactory service quality, as waiting times longer than 20 minutes indicate a poor bus service quality [2, 40]. The long waiting experienced could be attributed to lack of scheduled bus timetable as affirmed to the researcher by some anonymous management personnel of the operators at the terminal. Because, public transit passengers who are aware of scheduled bus timetable experience shorter waiting time at terminal than those who used unscheduled bus [2].

In relation to BSF, Enugu – Nsukka and Enugu – Oji River routes recorded higher daily BSF (21 to 30), hence, recorded lower waiting times compared to the other 4 routes (with daily BSF of 7 to 9). This implies that passenger's waiting time increases with decrease in BSF.

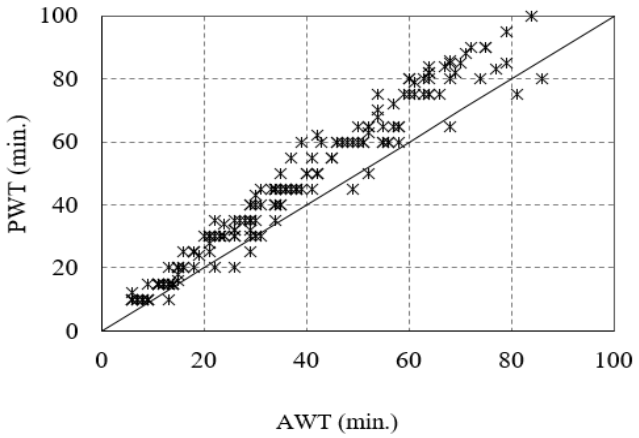

Figure 2: PWT – AWT for Enugu – Awgu

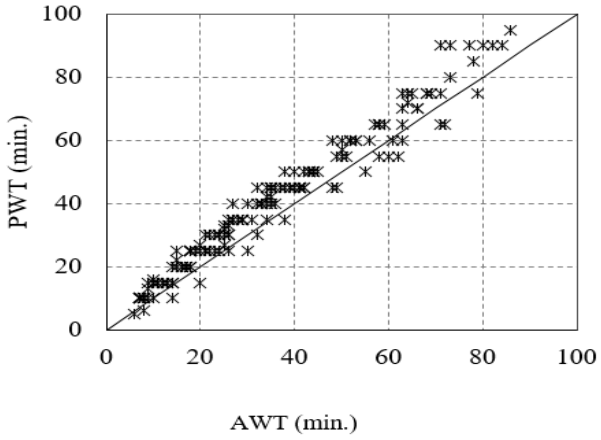

Figure 3: PWT – AWT for Enugu – Isi-Uzo

3.3 Comparison between Perceived and Actual Waiting Times

Subsequent to the data generated on passenger's waiting times from the two approaches, comparative analyses (using graphical and statistical approaches) were performed between the duo to examine whether AWT values are consistent with those of PWT or otherwise. Figures 2 – 7 show the graphical relations between PWT and AWT for the 6 routes; that is from Enugu city to each of the 6 LGAs.

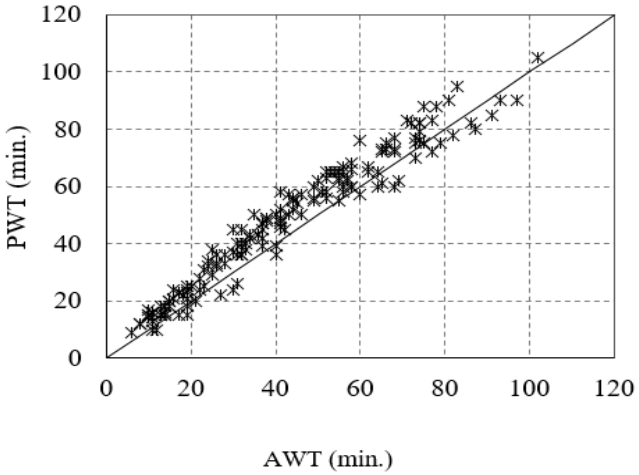

Figure 4: PWT – AWT for Nkanu – West

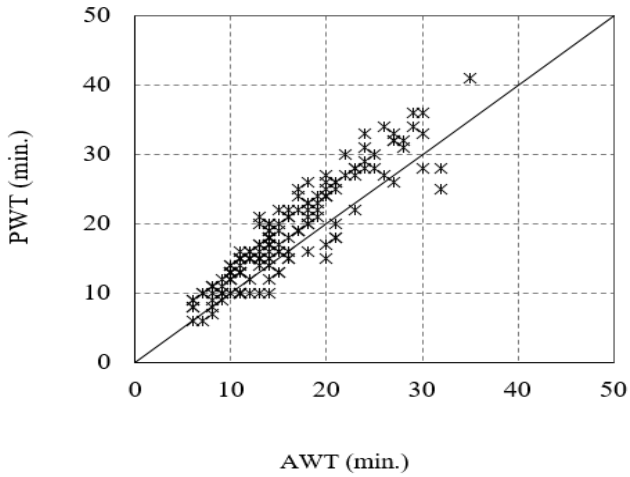

Figure 5: PWT – AWT for Enugu – Nsukka

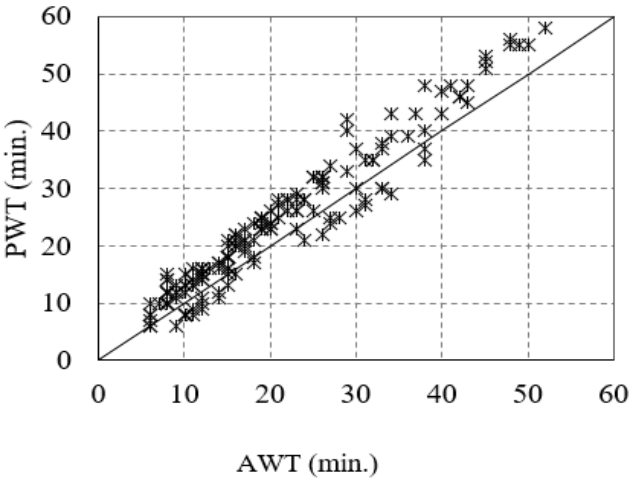

Figure 6: PWT – AWT for Enugu – Oji River

© 2023 by the author(s). Licensee NIJOTECH.
This article is open access under the CC BY-NC-ND license.
http://creativecommons.org/licenses/by-nc-nd/4.0/

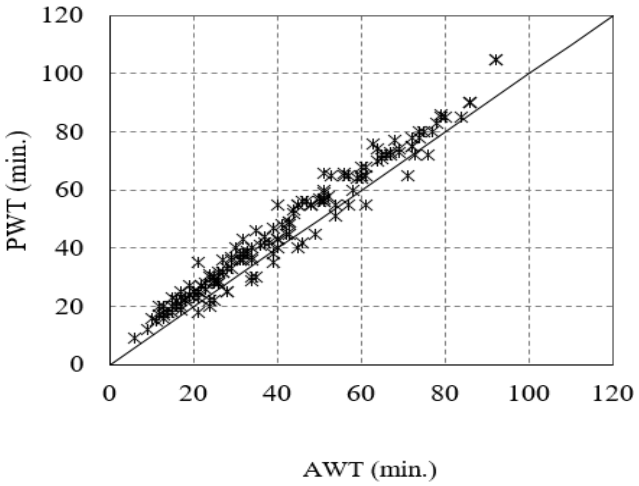

Figure 7: PWT – AWT for Enugu – Udenu

For the graphical analyses shown in Figures 2 – 7, the scattered points designate the relationship between the two data sets, while the diagonal is a plot of 1:1 (45^o) – line that serves as a guide in making the comparison between PWT and AWT values. In Figures 2 – 7, the relationships between PWT and AWT showed that larger proportion of the data points are scattered above the 45^o – line. These points are distributed within the region corresponding to PWT, implying that substantial proportion of the bus transit users perceived their waiting times longer than the actual time waited. On the other hand, the fewer data points below the diagonal correspond to AWT of the transit users, indicating that AWT values are longer than the PWT values. While those on the diagonal showed that PWT and AWT have equal values.

For all the 6 routes evaluated, 80 – 90% of sampled bus transit users overestimated their PWT, with the PWT being higher than the AWT by 25 – 60%. This appears to be on the high side relative to the AWT, which could be attributed to the anxiety by the passengers to travel, discomfort feelings at the terminal and being eager to meet up with their planned schedules. This finding appear to be consistent with those established earlier [6, 12, 29, 30]. It is therefore evident that PWT of the bus public transit routes studied were substantially overestimated by the passengers.

Irrespective of AWT and PWT, an interesting finding deduced from the passengers' waiting times is that Enugu – Nsukka and Enugu – Oji River routes recorded lower values (Figures 5 and 6) compared to the other 4 routes. This is attributed to the fact that these routes are particularly having higher bus service frequencies (BSF), thus, operating at shorter headways with resultant shorter waiting times to passengers. The finding is consistent with assertion that increase in BSF reduces waiting time at terminal [39]. This finding suggests that the bus transit operating on the studied routes should improve their frequency by shortening bus headways with increased BSF so that passengers' waiting can be reduced. The transit users' waiting times can be further reduced by shifting from unscheduled to scheduled operation, provision of real-time information system on bus arrival and departure, convenient waiting shelter with good seats and other terminal amenities. These were found to have reduction effect on passengers' perceived waiting time, as they improve the customers' comfort [9, 33, 41 – 45].

In order to have more insights, the difference between PWT and AWT for the 6 routes were evaluated to examine whether they are statistically significant or otherwise. To achieve that a test of significance was performed at 95% confidence level ($\alpha = 0.05$). The analysis revealed that PWT is significantly larger than AWT as the P-values between them for all the routes are much lower than 0.05. This suggests that PWT of bus public transit passengers significantly differs from AWT or PWT as overestimated by the transit users is significantly higher than the actual waiting time incurred at the terminal.

The comparative analysis between PWT and AWT for the studied routes showed that transit users perceived their waiting times as significantly longer than the actual for the respective data sets of each route. For that reason, the entire data sets from the 6 routes were subsequently aggregated and the waiting times derived from the two methods compared to examine whether the difference is significant or otherwise. The graphical comparison for combined data sets is shown in Figure 8.

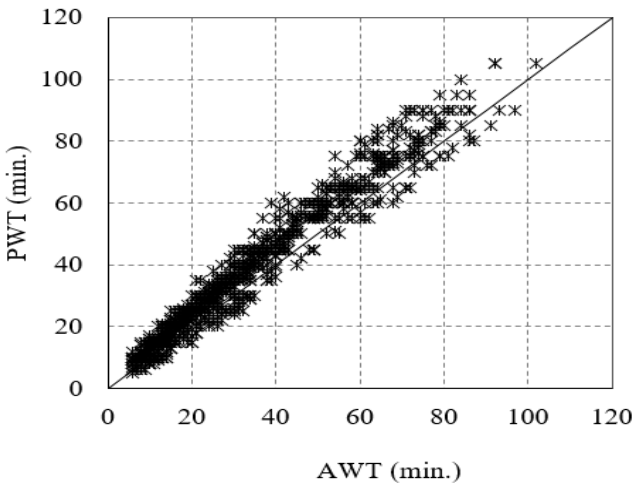

Figure 8: Combined Plots for PWT – AWT Relation for Studied Routes

© 2023 by the author(s). Licensee NIJOTECH.
This article is open access under the CC BY-NC-ND license.
http://creativecommons.org/licenses/by-nc-nd/4.0/

From Figure 8, larger proportion of the data points are scattered above the 45° – line, indicating that PWT of the transit users are substantially longer than the AWT. A statistical test of significance between PWT and AWT was performed at 95% confidence level, which showed that PWT is significantly longer than AWT, as confirmed by P-value being much lower than 0.05 (P < 0.05). This finding confirmed the assertions by others that bus transit users generally overestimate their waiting times [6, 28 – 30].

Overestimation of PWT by the passengers may be due to their long waiting time they incurred, as one of the effects of long waiting time at bus terminal is that it causes (and increases) discomfort and irritation levels to passengers [19]. This is more worrying when there are no convenient waiting shelter and real-time information (RTI) system for bus arrival and other amenities for passengers as is the case with bus terminal used for this study. RTI system allows passengers to estimate bus arrival time and appropriately plan their arrival time to the terminal [41, 44]. Earlier studies discovered that presence of RTI and basic amenities significantly reduces PWT at bus terminal [9, 33, 41 – 45] by up to 20% [6, 46].

3.4 Passenger's Perceived Waiting Time Model

Prior to the development of passenger's perceived waiting time model; a correlation analysis was performed between the model's input variables (PWT and AWT) to determine the extent of correlation between them. Result from the analysis revealed a correlation coefficient of 0.9794 between PWT and AWT. This shows a strong correlation between the variables; hence, they can be used to develop the model. Subsequent to this, the perceived waiting time model was developed based on the procedure described in Section 2.3. The summary of the model's output is shown in Table 1.

Table 1: Summary of Model's Output

(a) Regression Statistics	
Multiple R	0.9793
R Square	0.9591
Adjusted R Square	0.9591
Standard Error	4.5929
Observations	1050

(b) ANOVA	Df	SS	MS	F	Significance F
Regression	1	481582.9	481582.9	22829.95	0
Residual	1046	20524.8	21.09435		
Total	1050	502107.7			

(c) Coefficients						
Model	Coefficients	Standard Error	t Stat	P-value	Lower 95%	Upper 95%
Intercept	2.8074	0.2706	10.3756	5.41E-24	2.2764	3.3383
AWT	1.0606	0.0070	151.0958	0	1.0469	1.0744

From the regression analysis output shown in Table 1c, the resulting mathematical form of the passenger's perceived waiting time model is shown in Equation 3.

$$PWT = 1.0606AWT + 2.8074 \quad (3)$$

Based on the model's output in Table 1, it was discovered that the PWT is strongly correlated with AWT, as evidently affirmed by the high value of $R^2 = 0.9591$. This indicates that AWT accounts for an approximate of 96% variability in PWT. Further, the effect of AWT on PWT is significant enough, as indicated by P – value associated with AWT in Table 1c, which is approximately equals to zero or much less than 0.05 (P < 0.05). Thus, the perceived waiting time model developed in this study exhibits a reasonable accuracy. On the basis of overall significance, the AWT significantly contributes to the amount of variation in PWT. This is well supported by the test of significance from analysis of variance (ANOVA) shown in Table 1b, which indicates that AWT is significantly related to the PWT as the p-value is largely less than 0.05 (or approximately equals to zero). The finding implies that PWT is reasonably well correlated with AWT, and therefore the passengers' perceived waiting time model developed in this study exhibits a reasonable accuracy. The line of the model's best fit is shown with the red trend-line shown in Figure 9.

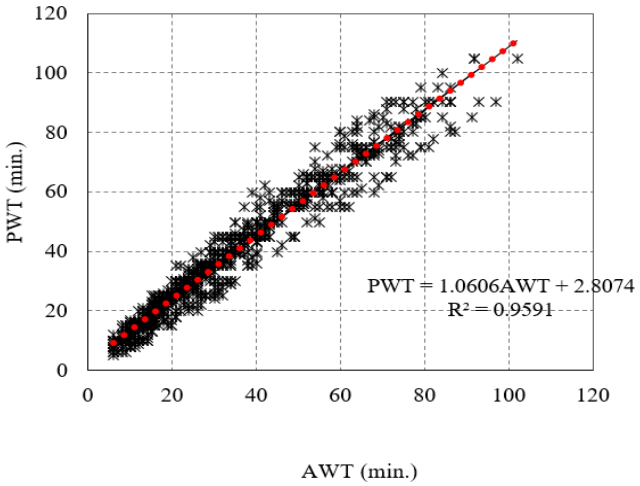

Figure 9: Model's fitting

To further assess the strength or otherwise of the transit users' perceived waiting time model, residuals plots (distribution of random errors) were generated as shown Figure 10. A close examination of the random errors distribution in Figure 10 showed that the residuals are randomly distributed around the horizontal axis. This implies that the residuals approximate the random errors that make the relationship between PWT and AWT, hence, the

© 2023 by the author(s). Licensee NIJOTECH.
This article is open access under the CC BY-NC-ND license.
http://creativecommons.org/licenses/by-nc-nd/4.0/

passenger's perceived waiting time model reasonably fits the observed data.

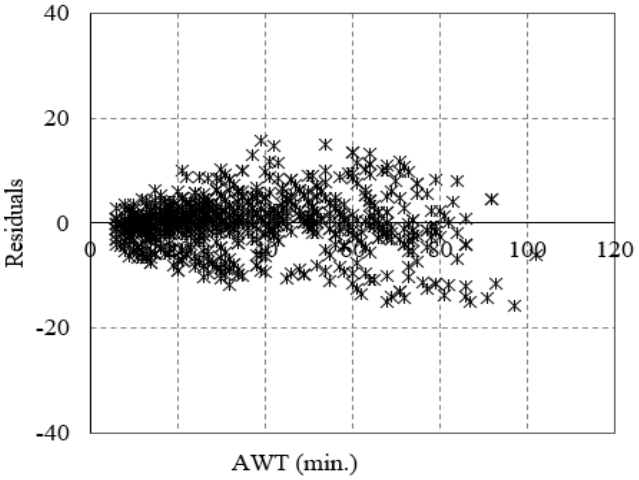

Figure 10: Residuals Plot for PWT – AWT Relationship

4.0 CONCLUSIONS

This study evaluated bus public transit passengers' waiting times at terminal; specifically, the passengers' perceived and actual waiting times along with the associated bus service frequency. Six bus routes departing from Old Park, Enugu (origin) to 6 local government areas (LGA) as destinations were examined. The bus transit routes covered within the stated local governments are Enugu – Awgu, Enugu – Isi-Uzo, Enugu – Nkanu West, Enugu – Nsuka, Enugu – Oji River and Enugu – Udenu routes. The summary of the key findings from the study and implications are summarized as follows:

i. The study discovered that the bus operation is an unscheduled system. The transit users incurred long waiting times, with perceived waiting time (PWT) being substantially longer than actual waiting time (AWT). For the 6 routes studied, 80 – 90% of the passengers experienced AWT ranging from 21 minutes to 1 hour and more (up to around 100 minutes). Similar trends were recorded for the passengers' PWT.
ii. A comparative analysis between PWT and AWT showed that for the 6 routes, 80 – 90% of the sampled bus passengers overestimated their PWT, with the PWT being higher than the AWT by 25 – 60% and even more. An analysis using test of significance at 95% confidence level revealed that PWT is significantly longer than AWT as the P-values between them for the 6 routes are much lower than 0.05.
iii. A passenger's perceived waiting time model was developed for prediction of PWT based on AWT. Consequently, the PWT was discovered to be strongly correlated with AWT as evidently affirmed by an R^2 value of 0.9591, which suggests that AWT accounts for 96% variability in PWT. This implies that the model developed in this study exhibits a reasonable accuracy, hence, can be applied for prediction of passenger's perceived waiting time at bus public transit terminal.
iv. On the studied routes' daily bus service frequency (BSF), Enugu – Nsukka and Enugu – Oji River routes recorded higher BSF of 30 and 21 buses per day, respectively. While, Enugu – Awgu, Enugu – Isi-Uzo, Enugu – Nkanu West and Enugu – Udenu routes recorded considerably lower BSF in the range of 7 to 9 buses per day. The lower BSF values for these routes resulted in longer waiting times compared to those for Enugu – Nsukka and Enugu – Oji River routes. The study discovered that increase in BSF reduces passenger's waiting time (and vice-versa) at bus terminal.
v. This research contributes to existing literature, as information on the bus public transit users' waiting times for the studied routes and similar ones would help in developing appropriate improvements on the existing operating system. Furthermore, the model developed in this study can be applied for prediction of passenger's perceived waiting time (based on actual waiting time) at bus public transit terminal with reasonable accuracy as affirmed by the statistical inferences. For future works, the current study suggests that wider duration for the data collection should be used to cover for early and late hours of the day (say from 6 am to 8 pm) and also to include weekend days.

REFERENCES

[1] Mabogunje, A. L. "The Challenge of Mobility in Nigeria's Emerging Megacities", presented at the Keynote Address Delivered at the *2008 LAMATA National Conference on Public Transportation*, Lagos, 2008.
[2] Ali, A. N. "An assessment of the quality of intraurban bus services in the city of Enugu, Enugu State, Nigeria", *Theoretical and Empirical Researches in Urban Management*, vol. 5, pp. 74-91, 2010.
[3] Lyndon, H., and Todd, A. "Evaluating new start transit program performance: comparing rail and bus", *Victoria Transport Policy Institute, Canada*, 2006.
[4] Aderamo, A. "Transport in Nigeria: The case of Kwara state", *African Economic and Business Review*, vol. 8, pp. 19-40, 2010.
[5] Nwachukwu, A. A. "Assessment of passenger satisfaction with intra-city public bus transport services in Abuja, Nigeria", *Journal*

© 2023 by the author(s). Licensee NIJOTECH.
This article is open access under the CC BY-NC-ND license.
http://creativecommons.org/licenses/by-nc-nd/4.0/

of Public Transportation, vol. 17, pp. 99-119, 2014.

[6] Mishalani, R. G., McCord, M. M., and Wirtz, J. "Passenger wait time perceptions at bus stops: Empirical results and impact on evaluating real-time bus arrival information", *Journal of Public Transportation*, vol. 9, pp. 89-106, 2006.

[7] Chepuri, A., Elluri, V. P., and Bijivemula, S. K. R. "A study on bus user's perception in selected Indian cities", *Materials Today: Proceedings*, vol. 65, pp. 3177-3184, 2022.

[8] Rhamdani, W. E., and Widyastuti, H. "The analysis of quality service suroboyo bus based on passenger's perception", in *AIP Conference Proceedings*, 2023.

[9] Fan, Y., Guthrie, A., and Levinson, D. "Waiting time perceptions at transit stops and stations: Effects of basic amenities, gender, and security", *Transportation Research Part A: Policy and Practice*, vol. 88, pp. 251-264, 2016.

[10] Wang, P.-C., Hsu, Y.-T., and Hsu, C.-W. "Analysis of waiting time perception of bus passengers provided with mobile service", *Transportation Research Part A: Policy and Practice*, vol. 145, pp. 319-336, 2021.

[11] Ingvardson, J. B., Nielsen, O. A., Raveau, S., and Nielsen, B. F. "Passenger arrival and waiting time distributions dependent on train service frequency and station characteristics: A smart card data analysis", *Transportation Research Part C: Emerging Technologies*, vol. 90, pp. 292-306, 2018.

[12] Yoh, A., Iseki, H., Smart, M., and Taylor, B. D. "Hate to wait: Effects of wait time on public transit travelers' perceptions", *Transportation Research Record*, vol. 2216, pp. 116-124, 2011.

[13] Mogbojuri, A., Olanrewaju, O., and Adeyeye, A. "Linear programming model for scheduling bus rapid transit in Lagos State, Nigeria", *Nigerian Journal of Technology*, vol. 42, pp. 236-243, 2023.

[14] Guo, S., Yu, L., Chen, X., and Zhang, Y. "Modelling waiting time for passengers transferring from rail to buses", *Transportation Planning and Technology*, vol. 34, pp. 795-809, 2011.

[15] Ansari Esfeh, M., Wirasinghe, S., Saidi, S., and Kattan, L. "Waiting time and headway modelling for urban transit systems–a critical review and proposed approach", *Transport Reviews*, vol. 41, pp. 141-163, 2021.

[16] Ji, Y., Zhang, R., Gao, L., and Fan, Y. "Perception of transfer waiting time at stops and stations in Nanjing, China", 2017.

[17] Eboli, L., and Mazzulla, G. "How to capture the passengers' point of view on a transit service through rating and choice options", *Transport reviews*, vol. 30, pp. 435-450, 2010.

[18] Eboli, L., and Mazzulla, G. "Performance indicators for an objective measure of public transport service quality", *European Transport*, 2012.

[19] Ohmori, N., Hirano, T., Harata, N., and Ohta, K. "Passengers' waiting behavior at bus stop", in *Traffic and Transportation Studies: Proceedings of ICTTS*, 2004, pp. 2-4.

[20] Ibrahim, M. N., and Alhassan, H. M. "Influence of unscheduled stop and dwell time of minibus public transport on transit time in Kano Metropolis", *Nigerian Journal of Technology*, vol. 39, pp. 113-120, 2020.

[21] James, B. O., and Victor, O. A. "Comparative Analysis of Public Private Transport Operations in Urban Centres of Nigeria: Case Study of Lagos", *Journal of Advances in Civil Engineering and Management*, vol. 3, 2020.

[22] Pencheva, V., Georgiev, I., and Asenov, A. "Evaluation of passenger waiting time in public transport by using the Monte Carlo method", in *AIP Conference Proceedings*, 2021, p. 030028.

[23] Currie, G. "The demand performance of bus rapid transit", *Journal of public transportation*, vol. 8, pp. 41-55, 2005.

[24] ÇAPALI, B. "Comparison of passenger wait and travel time perceptions at bus stops", *Erzincan University Journal of Science and Technology*, vol. 16, pp. 598-607, 2023.

[25] Brakewood, C., Macfarlane, G. S., and Watkins, K. "The impact of real-time information on bus ridership in New York City", *Transportation Research Part C: Emerging Technologies*, vol. 53, pp. 59-75, 2015.

[26] Van Hagen, M., Galetzka, M., and Ptuyn, A. "Perception and evaluation of waiting times at stations of Netherlands Railways (NS)", in *Proceedings of the European Transport Conference held 17-19 October, 2007, Leiden, Netherlands*, 2007.

[27] Dziekan, K., and Kottenhoff, K. "Dynamic at-stop real-time information displays for public transport: effects on customers", *Transportation Research Part A: Policy and Practice*, vol. 41, pp. 489-501, 2007.

© 2023 by the author(s). Licensee NIJOTECH.
This article is open access under the CC BY-NC-ND license.
http://creativecommons.org/licenses/by-nc-nd/4.0/

[28] Furth, P. G., and Muller, T. H. "Service reliability and hidden waiting time: Insights from automatic vehicle location data", *Transportation Research Record*, vol. 1955, pp. 79-87, 2006.

[29] Hess, D. B., Brown, J., and Shoup, D. "Waiting for the bus", *Journal of Public Transportation*, vol. 7, pp. 67-84, 2004.

[30] Moreau, A. "Public transport waiting times as experienced by customers", *Public transport international*, vol. 41, 1992.

[31] Webb, A., Kumar, P., and Khani, A. "Estimation of passenger waiting time using automatically collected transit data", *Public Transport*, vol. 12, pp. 299-311, 2020.

[32] Tavassoli, A., Mesbah, M., and Shobeirinejad, A. "Modelling passenger waiting time using large-scale automatic fare collection data: An Australian case study", *Transportation research part F: traffic psychology and behaviour*, vol. 58, pp. 500-510, 2018.

[33] Watkins, K. E., Ferris, B., Borning, A., Rutherford, G. S., and Layton, D. "Where Is My Bus? Impact of mobile real-time information on the perceived and actual wait time of transit riders", *Transportation Research Part A: Policy and Practice*, vol. 45, pp. 839-848, 2011.

[34] Arama, Z. A., and Gençdal, H. B. "Simple regression models to estimate the standard and modified proctor characteristics of specific compacted fine-grained soils", in *Proceedings of the 7th World Congress on Civil Structural, and Environmental Engineering, Lisbon, Portugal*, 2022, pp. 10-12.

[35] Bareth, R., Kochar, M., and Yadav, A. "Electrical Load Forecasting based on Multiple Regression using Excel Tools", in *2023 Third International Conference on Advances in Electrical, Computing, Communication and Sustainable Technologies (ICAECT)*, 2023, pp. 1-4.

[36] Outram, J. G., Couperthwaite, S. J., Martens, W., and Millar, G. J. "Application of non-linear regression analysis and statistical testing to equilibrium isotherms: Building an Excel template and interpretation", *Separation and Purification Technology*, vol. 258, p. 118005, 2021.

[37] Sankaran, S., Sankaran, K., and Bui, T. "Student satisfaction with R vs. Excel in Data Mining and Business Analytics: A Herzberg's motivation-hygiene theory perspective", *Decision Sciences Journal of Innovative Education*, vol. 21, pp. 68-82, 2023.

[38] Titu, A. M., Boroiu, A. A., Boroiu, A., Dragomir, M., Pop, A. B., and Titu, S. "Reliability Modelling through the Three-Parametric Weibull Model Based on Microsoft Excel Facilities", *Processes*, vol. 10, p. 1585, 2022.

[39] Chien, S. I. J. "Optimization of headway, vehicle size and route choice for minimum cost feeder service", *Transportation Planning and Technology*, vol. 28, pp. 359-380, 2005.

[40] Armstrong-Wright, A., and Thiriez, S. "Bus Services: Reducing Costs", presented at the *Raising Standards, Urban transport series*, The World Bank: Technical paper No. 68, 1987.

[41] Brakewood, C., Barbeau, S., and Watkins, K. "An experiment evaluating the impacts of real-time transit information on bus riders in Tampa, Florida", *Transportation Research Part A: Policy and Practice*, vol. 69, pp. 409-422, 2014.

[42] Wen, C.-H., Lan, L. W., and Chen, C.-H. "Passengers perception on service quality and their choice for intercity bus services", in *Transportation Research Board, 84th Annual Meeting*, 2005.

[43] Schweiger, C. "Customer and media reactions to real-time bus arrival information systems", *Transportation Research Board, Report No*, vol. 48, 2003.

[44] Lu, H., Burge, P., Heywood, C., Sheldon, R., Lee, P., Barber, K. *et al.*, "The impact of real-time information on passengers' value of bus waiting time", *Transportation Research Procedia*, vol. 31, pp. 18-34, 2018.

[45] Cats, O., and Gkioulou, Z. "Modeling the impacts of public transport reliability and travel information on passengers' waiting-time uncertainty", *EURO Journal on Transportation and Logistics*, vol. 6, pp. 247-270, 2017.

[46] Dziekan, K., and Vermeulen, A. "Psychological effects of and design preferences for real-time information displays", *Journal of Public Transportation*, vol. 9, pp. 1-19, 2006.

© 2023 by the author(s). Licensee NIJOTECH.
This article is open access under the CC BY-NC-ND license.
http://creativecommons.org/licenses/by-nc-nd/4.0/