Proceedings of the 4th International Conference on Civil Engineering for Sustainable Development (ICCESD 2018), 9~11 February 2018, KUET, Khulna, Bangladesh (ISBN-978-984-34-3502-6)

RELATIONSHIP BETWEEN DWELL TIME AND NUMBER OF PASSENGER BOARDING: A REFLECTION OF BATTERY BIKE IN KHULNA CITY, BANGLADESH

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ABSTRACT

This research intends to find out the relationship between no of passenger(s) boarding and battery bike dwell time. It also tries to observe the variations in dwell time during peak and off peak hour of a day. This study was conducted in Khulna city (the third largest city of Bangladesh). The data has been collected on 10 variables from two intermediate stoppage during different time of a day. These variables have been selected based on literature review and visual observation and analyzed by multiple regression. The study showed that battery bike dwell time and the influencing factors vary based on time. It is also found that dwell time depends on payment duration, waiting time, boarding and alighting time instead of number of boarding and alighting passengers. But during off peak hour, number of boarding passenger plays an important role in the dwell time. Besides, passenger behavior has an impact on boarding and alighting time. In this paper, it is also recommended the maximum dwell time, the battery bike should spend at each stoppage during different period of a day. Therefore, the result of this research will help the transportation agencies and decision makers to ensure overall reliability and quality services as well as to reduce traffic congestion through schedule planning.

Keywords: *Passenger, battery bike, dwell time, Khulna, Bangladesh*

1. INTRODUCTION

Success of a public transport largely depends on how well it is designed (route, vehicle, ticketing, fare etc.) for the target people and its reliability on performance. One of the significant factors for public transport reliability and quality is dwell time. Dwell time is the amount of time the public transits stop at the stoppage for boarding or alighting passengers (Li et al., 2012). Dwell time is influenced by several factors e.g. no of passengers boarding and alighting, payment method, weather condition, traffic, location of the stoppage, parking space, time of the day and so on (Gopinath et al., 2015). It is found that dwell time contributes a lot to the total travel time of the public transport. For example, dwell time consumes 26% of total travel time of the public bus (Fletcher and Geneidy, 2013).

There are several types of public transport all over the world like metro rail transit (MRT), light rail transit (LRT), bus rapid transit (BRT) and so forth. In developing countries high-end public transport like MRT and LRT is not practiced for high capital and operating cost. As a result, Motorized vehicles (MT) are dominating in both public and private sector of these countries. Among this, MT vehicles, bus, minibus, CNG driven auto rickshaw and taxi are very common in Bangladesh. In 2009 battery bike as a MT was first introduced in Bangladesh. In Khulna, like other cities in Bangladesh, battery bike became a major transportation mode, especially for the low income peoples and students due to its low cost and availability. Every day approximately 17,000 battery bikes are running in this city providing more than half (65%) of the total transport demand in Khulna city (Lubna et al, 2014). This increasing number of battery bikes is also causing traffic congestion in the cities due to lack of fixed dwell time at the stoppage along with haphazard parking and stopping on road.

Dwell time plays an important role on system performance, service reliability and quality for any mode of public transport. Till now no literature has been found on battery bike dwell time analysis. Most of the earlier studies on dwell time analysis were found particularly for public bus and train considering different variables. For example, San and Masirin (2016) and Shockley et.al (2016) found that dwell time is sensitive to passenger volume (total number of passenger boarding and alighting). It is also found that "passengers alighting will not contribute to overall dwell time unless there are far more of them than boarding passengers" (Shockley et al., 2016). Another research by Ahrin (2016) has identified that dwell time varies during different time of the day.

In Khulna city the battery bike runs both as transit and paratransit. It can carry 6 persons per trip with an average speed of 30km/h (Iqbal et al., 2013). Khulna University Masters of Urban and Rural Planning Discipline (Batch 16, 2017) found that these types of three wheelers stop suddenly here and there for boarding or alighting passengers. The hypothesis of the research is that Battery bike dwell time increases if the number of passenger boarding increases. In line of the hypothesis, the objective of this research is to find out the relationship between the Battery bike dwell time on the stoppage and the number of passenger(s) boarding. Furthermore, this study attempts to see the variation in dwell time during different time of a day, e.g., peak hour and off peak hour. In doing so, this research can contribute to the broader understanding about the motorized three wheelers in Khulna city and beyond. In addition, the findings of this research can help the transportation agencies and decision makers to ensure overall reliability and quality services as well as to reduce traffic jam through schedule planning.

2. THEORETICAL FRAMEWORK

This study explores the factors affecting battery bike dwell time. First, in general terms, battery bike is a battery driven three wheeler. Secondly, dwell time refers to the time in which the public transport stops at a station for serving the passengers. The dwell time therefore depends on number of passenger boarding and alighting. It basically begins when the public vehicles stop at a station and lasts till to move away (Li, 2012; Zhang and Teng, 2013, Fernandez et al., 2010).

Li et al, (2013) recommends two aspects of dwell time for studying: (1) dwell time method which reveals the relationship between dwell time and relevant factors; and (2) Physical factors affecting dwell time e. g platform, boarding floor and vehicle floor height, number of doors, payment methods and so forth. This study focuses on the former aspect as it suits well with battery bike.

2.1 Factors Affecting Dwell Time

Several factors affect dwell time. Gopinath et al. (2015) divide these factors into two parts: person/passenger variables and design factors. Person variables include number of passenger boarding and alighting, platform and door crowding and congestion, human behavior and human choice. Design factors comprise type of vehicles, number of doors for getting in and out, payment method and location. Again Jaiswal et al. (2009; 2010) divide the dwell time data into two components: bus side data and passenger side data. The bus side data contains queuing time, and door opening and closing time. The passenger side data comprises walking time from waiting position to bus door, platform density, and queuing time. Besides, there are another factors related to weather which affect dwell time, e. g, time of a day and weather condition (Zhang and Teng, 2013).

2.2 Prior Studies on Dwell Time Factors

Several scholars have conducted researches considering different factors to estimate public transit dwell time. For example, Jaiswal et al. (2010) and Li et al., (2012) found that dwell time is significantly dependent on number of passenger alighting and boarding. Shalaby and Farhan (2003) assumed that boarding passengers at each bus stop have a more significant effect on bus dwell time at that stop than alighting passengers. Sometimes, this passenger boarding and alighting process becomes affected by the passenger profile. For example, passengers with strollers or luggage and those who require special assistance (visually impaired and on wheelchairs) would extend the process of boarding and alighting (Douglas, 2012).

Along with passenger alighting and boarding factors, several researchers took into account several other factors in order to get more accurate result. For example, speed of boarding and alighting passenger, passenger conflict, fare collection method, vehicle capacity, crowding and so forth. According to Weston (1989) dwell time depends on speed including number of passenger boarding and alighting and found that mixed flow of passengers requires more dwell time than uni-directional flow.

In spite of this, Peng and Yang (2002) found that the location and the waiting point of the bus stop along with period of time influence the dwell time. For example, on hills, the effect of gravity on already weak diesel engines can lead to considerable additional delay if a bus has to accelerate from a stop (Furth and San Clemente, 2006). Jaiswal et al (2010) established that passenger walking distance from station to bus door leads the bus to experience higher dwell time.

On the other hand Zang and Teng (2013) proved that crowding, fare collection method, vehicle capacity along with passenger boarding and alighting number increases the dwell time accuracy. For example, Jaiswal et al. (2007) suggested that platform crowding pattern has a significant effect on dwell time. It affects the passengers' maneuverability and obstructs the clear line of sight to approaching buses. Dorbritz et al. (2008) and Jaiswal et al (2009) found that the payment method could affect the bus dwell time. Farnandez et al (2009) showed that the dwell time variability is affected by the platform height, door width and fare collection method. Result shows that by removing on board ticketing system, the boarding time could decreased by about 15%.

Furthermore, after analyzing the boarding process at a bus stop and a busway station, Jaiswal et al. (2009) established that at the bus station where boarding is predominant, an increase in the platform crowd increased the passenger–bus interface duration which leads to loss of time for buses and increases the bus dwell time. Furthermore, according to Li et al. (2012) conflict between the boarding and alighting passengers also rises dwell time.

In case of train, it is found that dwell time is very much influenced by the passenger volume, though at different rates due to factors such as door widths, platform gaps and movement of passengers. A mixed flow of passengers and on-board crowding are also expected to increase dwell time (San et al., 2016).

Additionally, to find out the weather impact on dwell time, Bladikas et al. (2009) examined bus travel time in different weather condition and found that bus dwell time (boarding and alighting times) increases in bad weather condition.

2.3 Methods

Several types of statistical models are used in dwell time analysis. Traditionally, linear regression model were used for finding the relationship between dwell time and its relevant factors (Rashidi and Ranjitkar, 2015). Levinson (1983) used a regression approach for developing bus dwell time and established the total number of boarding and alighting passengers is the major factor of bus dwell time. However due to its simplicity and achieving more accuracy, some scholars use non-linear approach e.g. multiple logit model, error component model (Tirachini et al., 2013; Li et al., 2012). For example Li et al. (2012) perform non-linear regression model considering number of passenger boarding or alighting. They also added number of standing commuters on vehicles and platform and found that conflict between the boarding and alighting passengers also rises dwell time. Kittelson and Associates (2003) established a multivariate linear regression model for dwell time estimation considering boarding and alighting passengers as separate variables. Beside these, statistical simulation technique is another approach for dwell time modelling. Time series data like moving average, random walking is also used by some scholars for predicting dwell time (Rashidi and Ranjitkar, 2015).

From the above discussion, it can be concluded that all researches on dwell time analysis are particularly for public buses and trains. However, no research has been conducted in Bangladesh with empirical data on public bus or battery bike.

Battery bikes are a distinct identity of public transport in all divisional cities, Bangladesh – they are virtually everywhere. It is being extensively used for short distance travel providing cheap alternative to rickshaw and other modes of public transport like bus, van and auto-rickshaw. Recent study by Lubna et al., (2014) found that battery bike has the highest spatial coverage. Because they are best suited to narrow and crowded streets. As a result, they can cover longer distances within urban areas (Iqbal et al., 2013). Besides, they have high level of customer satisfaction due to low cost and high comfort. Apart from these, battery bike is an ideal example of green transport due to low air pollution, economic and social importance. In spite of these advantages, battery bikes become the main causes of traffic congestion in Khulna city. Because this types of three wheelers stop/park suddenly here and there for boarding or alighting passengers which hampers other vehicle's movement.

Therefore, it's out most important to identify the factors affecting battery bike's dwell time. This research attempts to find out the relationship between the number of passenger boarding and battery bike dwell time through linear regression model. From a preliminary reconnaissance survey and literature review, a list of factor that might affect the dwell time of battery bike is identified. The list wise data collection is mentioned in the following section

3. METHODOLOGY

There are five main Battery bike routes in Khulna City, Bangladesh. These are*: Rupsha-Shibbari*, *Shibbari-Shonadanga, Gollamari-Powerhouse, Gollamari-Notunrasta, Dakbangla-Notunrasta* (Figure 1). This routes are not declared by any authorities. Most of the times it is fixed by the drivers and the demand of the passengers. The data of this study were collected from two intermediate stoppage (*Nirala More* and *Moilapota More*) due to limited time and manpower. This stoppage are located on *Gollamari- Power house* route. The length of this route is approximately 4 km (*Gollamary to Power house*) consisting 4 battery bike stoppage. This stoppages are selected based on the location at the intersection with high passenger demand and ease of access. The data on the dwell time were collected from 120 battery bikes on Monday at peak and off peak hour (7-8 pm and 11-12 am) due to different traffic dynamics. The data has been collected on the following variables for conducting multiple regression model –

1. Dwell time (Dt)
2. Negotiation time (Nt)
3. Boarding Time (Bt)
4. Alighting Time (At)
5. No of passenger boarding (Nb)
6. No of passenger alighting (Na)
7. Payment duration (Pd)
8. Waiting time (intentional wait, crowded stop, passenger behavior) (Wt)
9. Passenger with load (children, lagudge) (Pl)
10. Gender of the passenger (Gp)

The data extraction has been done manually. For example, to record the time of different variables in SPSS software by observing the video.

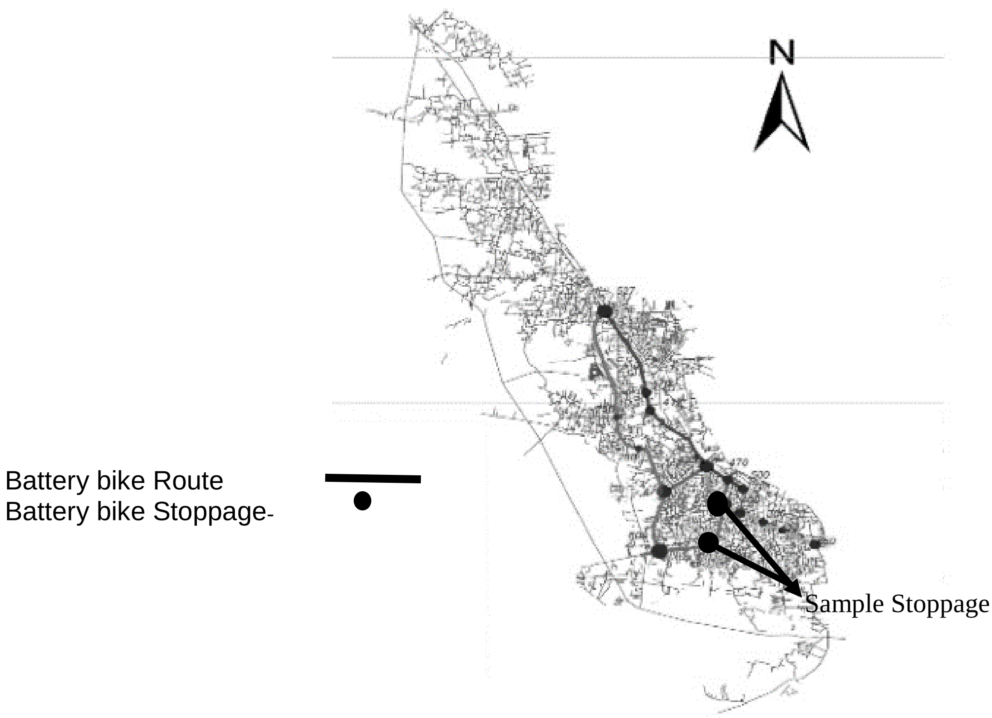

Figure 1: Battery bike Route in Khulna City.

4. ANALYSIS AND FINDINGS

4.1 Dynamics of the Dwell Time Factors in Different Time of a Day

For this analysis descriptive statistics has been performed to see the variation in dwell time factors in different time of a day. The number of total battery bikes are more or less the same in all the time even though the passenger's travel behavior varies with the time of a day (peak hour and off peak hour) (Figure 2, 3, 4, 5). Every day, approximately 1200/h battery bikes are found in both direction during peak and off peak hour at each stoppage. From the table 1, it is found that the longest dwell time took place during off peak hour with 20s due to large number of boarding passengers with long boarding time and also the lengthy payment duration. From the visual observation, it is found that this long boarding time also depends on passengers' behavior. For example, sometimes passengers come from the opposite side of the road to board on, especially female passengers sometimes board in with their children.

Sometimes, passengers take time for closing their umbrella in a hot or rainy day.

Figure 2: Passenger Closing Umbrella before Boarding

Figure 3: Women with children

Figure 4: Passenger Relocation

Figure 5: Presence of Police at Peak

Besides , during the off peak hour it took long waiting time due to the intension of new passengers, sometimes due to the crowded stoppage and sometimes for passengers relocation. However, it was during the evening period when the most number of passengers alighted with a long time. In this period, most of the passengers basically return to their origin. Sometimes, they meet their friends at the stoppage. Therefore, they alight with a relax mode which extends the time. On the other hand, in the peak hour, payment duration and waiting time is relatively low based on off peak hour because the presence of traffic police force the drivers to leave the stoppage as soon as possible.

Table 1: Mean Value of Variables Affecting Dwell Time

Variables	Peak hour	Off peak hour
Dwell time (s)	15.20	20.27
Negotiation time (s)	.98	.78
Boarding time (s)	1.91	3.08
No of Passenger Boarding (person)	.45	2.56
Alighting time (s)	1.90	.58
No of passenger alighting (person)	.93	.81
Waiting time (s)	2.21	4.50
Payment duration (s)	8.18	8.38

4.2 Factors Affecting Battery Bike Dwell Time

For estimating the factors influencing Battery bike dwell time, regression model has been performed based on the peak hour and off peak hour at 95% confidence level. Here, Dwell time is a dependent variable and rest are independent variable. It can be expressed in the following way: Dt = f (Nt, Bt, At, Nb, Na, Pd, Wt, Pl, Gp).

From the result, it is found that gender of the passengers (sig. peak = .776, off peak =.482) and the passengers with load (sig. peak= .769; off peak =.097) do not affect the battery bike dwell time. But during the morning hour no of passenger alighting (sig .778) and during the evening hour (peak hour) no of passenger boarding (sig .441) does not have significant influence on dwell time. Therefore, the models of this two period are following –

Table 2: Dwell Time Regression Model

Time Period	**Regression Model**	**R^2**	**ANOVA**	
			F	**P**
Peak Period	Dt= 1.05Nt + .96Bt + .97At + .26Na + .98Pd + 1.02 Wt	.99	5717.13	.00
Off period	Dt= .66Nt +.72Bt + 3.74Nb +1.05At + 1.01Pd + 1.046 Wt	.96	175.29	.00

The results based on the R^2 value that are 99% and 96% showed that the Dt models were adequate and could explain relatively high percentages of the variations in the data. And the results also showed the most prominent independent variables that predicts the battery bike dwell time. From the model equation (table-2) it is also understood that all the influencing factors are positively correlated with the dwell time.

4.3 Sugession and Recommended Dwell Time

It was assumed that to improve reliability, the battery bike dwell time should not exceed the maximum time at each stoppage and by time of the day. To achieve this, the maximum and minimum average of the significant variables at each period was used to obtain the minimum and maximum dwell time. For this, upper limit and lower limit of the 95% confidence interval of variables was taken as maximum average and minimum average respectively.

The summary of the minimum and maximum dwell time is presented in Table3. The maximum suggested dwell time in the off peak period for each battery bike stoppage should be no more than 25s (Table-3). On the other hand, the maximum dwell time during the peak period for each stops should not exceed 5s (Table-3).

Table 3: Minimum and Maximum Dwell Time at the Time of a Day

Peak Hour		**Off Peak Hour**	
Max	Min	Max	Min
5s	4s	25s	10s

5. DISCUSSION AND CONCLUSIONS

The target of this study was to find out the relationship between dwell time and numbers of passenger boarding. To find the dominant variables, data has been collected on 10 variable s from the two different points during different time of a day. These variables have been selected based on the secondary literature and visual observation. The study shows that battery bike dwell time and the influencing factors vary based on time period. It is also found that dwell time depends on payment duration, waiting time, boarding and alighting time instead of number of boarding and alighting passengers. But during off peak hour no of boarding passenger plays an important role in the dwell time. Besides, passenger behavior has an impact on boarding and alighting time.

However, the concept of dwell time prediction will enable the decision-makers to the improvement of overall reliability. Because, the models can be adequately used, at 95%

confidence interval, to predict the dwell time by the time of the day and it is recommended that during the peak hour and off peak hour battery bike should not spend more than 5s and 25s at each stoppage respectively. It should be noted that the models are based on data collected in Khulna city corporation area, therefore it would not be applicable in other jurisdiction. Besides, as travel pattern and density are subject to change, model updating is required in every 5 or 10 years.

Apart from these, this research has some limitations. Firstly, this study has dealt with limited no of variables, for example, it has not considered the weather condition, age of the passengers, engine problem and so forth which might have impact on the dwell time. Secondly, when boarding and alighting of the passengers happened simultaneously, boarding time was not considered because payment activities and boarding occurred at a time. Finally, presence of police force the battery bike to pass away during the peak hour. In the absence of them, there is a possibility to get extended dwell time.

ACKNOWLEDGEMENT

At first I would like to express my gratitude to the most generous and benevolent almighty Allah to carry out this work. I am indebted to Dr. Md. *Ahsanul Kabir*, professor, Urban and Rural Planning Discipline, Khulna University for his constant guidance and also thankful to the battery bike drivers for participating in the survey.

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