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Assessment of Tricycles as a Public Transportation Mode in Ibadan City, Nigeria

Evaluarea tricicletelor ca mod de transport public în orașul Ibadan, Nigeria

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Abstract. *Two road corridors in Ibadan City where the use of tricycles is prominent namely Mokola to Agodi Prison Gate Road (MAR) and Challenge to Orita Challenge Road (COR) were identified. Traffic volume data were collected from Monday to Friday during the peak periods, likewise the socio-economic characteristics of tricycle operators using questionnaires. Traffic volume counts revealed that the percentage of tricycles compared to other transportation modes ranged between 9.54% and 20.08% along MAR and between 13.27% and 19.61% along COR. The socio-economic characteristics data showed that 98.5% of the operators were male, their ages ranged between 18 and 60 years and 26.5% had a monthly income of more than N40,000. Tricycle had the second highest arrival rates along MAR and COR of 6.17 and 7.91 respectively.*

Key words: *corridors, traffic volume, socio-economic, arrival rates*

1. Introduction

The importance of urban transportation within any given setting cannot be over emphasized. This is because transportation is an integral part of almost all human activities and it affects the way in which societies are organized. It is a known fact that transportation is the heart beat of any city, whereby without it everything within the city or town would come to a standstill. Transportation plays a key role in the existence and survival of any urban community, this is because it forms the basis of interaction for work, leisure and residential activity, at the same time transport has a strong force in the emergence of early settlements [1].

In the Nigerian road transportation system, varieties of buses, taxis, omnibuses, vans and motorcycles are used to move material and people from one place to the other [2]. In the research on passengers' satisfaction with transport services in Nigeria, a high level of discomfort leading to lack of satisfaction of passengers with the available public transport services was noted [3]. One of the causes reported for the users' discomfort is poor condition of necessary facilities [4]. Others are non-compliance of seat design to standards, long term confined postures and whole-body vibrations [5].

In recent times, the use of paratransit (tricycle) has become popular for transportation [6]. The expansion of paratransit is gradually becoming a means of full public transport in some areas of the country due to poor public transport systems and road networks [7]. Assessment of tricycle operations revealed that the emergence of various modes of transportation occasioned by the need to cope with socio-economic trends and the adverse economic situation of the country gave rise to its operation and gave rise to its use [8]. It was reported that because of its relative affordability and availability, some passengers in some areas of the country prefer using it [9].

The low level of transport services provided by conventional transport systems have led to the expansion of paratransit operations along busy corridors in Nigerian cities. Bus systems and paratransit operations are major competitors. Typically, passengers wait at the curb for a bus to arrive and paratransit operators interlope on the scheduled service; the result is that passengers will probably board the vehicle that comes first.

Low-capacity vehicles operate in many cities as an alternative to public transport in developing countries, for instance in Aba City, Abia State, Nigeria. Some examples are auto rickshaws and cycle rickshaws, responsible for 15% of the public transport market in India [10]; *tuk-tuks* (a three-wheeled motorcycle) which are called *Keke Napeps* in Nigeria; while *silor-leks* (a small four-wheeled vehicle) play an important role in moving persons as well as goods in Bangkok, Thailand [11]. [12] presents examples of other low-capacity vehicles used for passenger transportation in different cities.

However, studies have revealed that ergonomics consideration for users' comfort is not common in the design of tricycles in the country. To minimize discomfort among public transport users, which should be paramount among other design considerations, there is need for proper assessment of seat design [13], access and exit door/stairs [14] among others

Therefore, this study intends to investigate the problems as well as assess the effectiveness of this paratransit mode of urban transportation and bring to the fore it economic, socio-political, strategic and ergonomic function.

2. Methodology

Ibadan is the capital and most populous city of Oyo State, in Nigeria. It is the third-largest city in Nigeria after Lagos and Kano, the 2006 National Population Census estimated the metropolis to be inhabited by 1.34 million people. To conduct a detailed assessment of tricycles as a public transportation mode in Ibadan, road corridors where the use of tricycles is prominent were selected. This is to ensure that the data collected is correct and can be used for the assessment of tricycle as a mode of transportation. Two routes where the use of tricycle is prominent were identified namely Mokola to Agodi Prison Gate Road (MAR) and Challenge to Orita Challenge Road (COR).

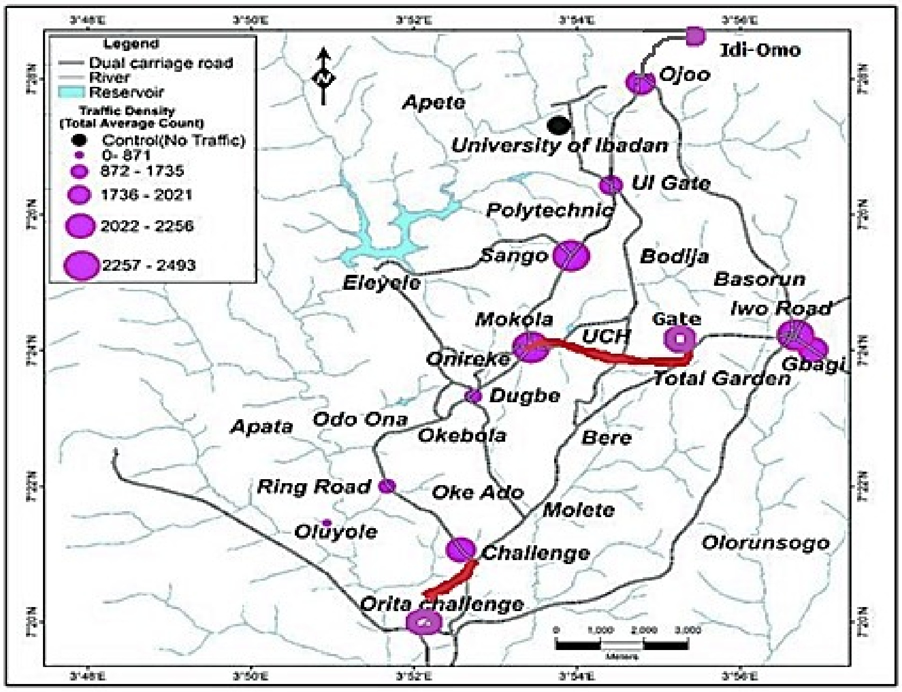

Figure 1: Map of Ibadan showing the MAR and COR routes

Along each route, data on traffic composition, traffic volume and tricycle occupancy were collected during the peak periods (7:00 am - 8:00 am and 3:00 pm- 4:00 pm). Data for the research was collected through an intensive field survey carried out for seven (7) days.

2.1 Experimental Setup

To determine the effectiveness of tricycle as a paratransit mode of transportation, the traffic volume and composition on the selected roads within Ibadan metropolis was measured. The traffic composition and volume data were collected with a digital video recording camera, which was positioned adjacent to the road to record the flow of traffic; vehicles were classified into motorcycles, tricycles, passenger cars, minibuses, lorries (2 axles) and trailer (3 axles). Traffic composition and volume data were extracted from the digital video camera recording.

The number of passengers in a vehicle during a trip known as vehicle occupancy was also measured. The most widely used roadside windshield method that involves stationing one or more observers along the roadside to count vehicles and occupants was used. For safety reasons, the observers stood in a protected area where they will be able to conduct the count without interfering with the free flow of traffic.

Slovin's formula in Equation 1 was used to determine the sample size from the population of study area based on the 2006 census figures for the local governments where the study locations were situated.

$$n = \frac{N}{(1+Ne^2)} \quad (1)$$

where n is the sample size;
N is the known population size; and
e is the margin of error.
Questionnaires were designed with well-structured questions to collect socio-economic data at the study locations. Both self-administered questionnaires and interviews were used in this research to ensure that a larger sample, as well as adequate distribution of the sample and the collection of a large amount of data in a relatively short time.

2.2 Poisson Distribution Function

Consider a time *t* in which some number *n* of tricycle may arrive at the bus park. Suppose that the events are independent, i.e., the occurrence of one event has no influence on the probability for the occurrence of another. Furthermore, suppose that the probability of a single event in any short time interval δt is

$$P(1;\delta t) = \lambda\delta t \quad (2)$$

where λ is a constant.
Consider also the time interval *t* broken into small subintervals of length δt. If δt is sufficiently short then the probability that two events will occur in it can be neglected. one event with probability

$$P(1;\delta t) = \lambda\delta t \quad (3)$$

and no events with probability

$$P(0;\delta t) = 1 - \lambda\delta t \quad (4)$$

To find is the probability of tricycles arrival times in time t, it can start by finding the probability to find zero events in t, $P(0;t)$ and then generalize this result by induction.

Suppose $P(0;t)$ is known, it could then ask what is the probability to find no events in the time $t + \delta t$. Since the events are independent, the probability for no events in both intervals, first none in t and then none in δt, is given by the product of the two individual probabilities. That is,

$$P(0;t + \delta t) = P(0;t)(1 - \lambda\delta t) \quad (5)$$

This can be rewritten as

$$\frac{P(0;t + \delta t) - P(0;t)}{\delta t} = -\lambda P(0;t) \qquad (6)$$

which in the limit of small δt becomes a differential equation,

$$\frac{dP(0;t)}{dt} = -\lambda P(0;t) \quad (7)$$

Integrating to find the solution gives

$$P(0\,;\,t) = Ce^{-\lambda t} \quad (8)$$

For a length of time t = 0 the number of events must be zero, i.e., the boundary condition is required
$P(0;0) = 1$. The constant C must therefore be 1 to obtain

$$P(0;t) = e^{-\lambda t} \quad (9)$$

Now consider the case where the number of events n is not zero. The probability of finding n events in a time $t + \delta t$ is given by the sum of two terms:

$$P(n;t + \delta t) = P(n;t)(1 - \lambda\delta t) + P(n - 1;t)\lambda\delta t \quad (10)$$

The first term gives the probability to have all n events in the first subinterval of time t and then no events in the final δt. The second term corresponds to having $n - 1$ events in t followed by one event in the last δt. In the limit of small δt this gives a differential equation for $P(n;t)$:

$$\frac{dP(n;t)}{dt} + \lambda P(n;t) = \lambda P(n-1:t) \quad (11)$$

We can solve equation (11) by finding an integrating factor $\mu(t)$, i.e., a function which when multiplied by the left-hand side of the q ` in a total derivative with respect to t. That is, a function $\mu(t)$ in needed such that

$$\mu(t)\left[\frac{dP(n;t)}{dt} + \lambda P(n;t)\right] = \frac{d}{dt}[\mu(t)P(n;t)] \quad (12)$$

the function can easily show that as

$$\mu(t) = e^{\lambda t} \quad (13)$$

has the desired property and therefore,

$$\frac{d}{dt}\left[e^{\lambda t}P(n;t)\right] = e^{\lambda t}\lambda P(n-1;t)] \quad (14)$$

using this result, for example, with n = 1 to find

$$\frac{d}{dt}\left[e^{\lambda t}P(1;t)\right] = \lambda e^{\lambda t}P(0;t)] = \lambda e^{\lambda t}e^{-\lambda t} = \lambda \quad (15)$$

where we substituted our previous result (9) for $P(0;t)$. Integrating equation (18) gives

$$e^{\lambda t}P(1;t) = \int \lambda dt = \lambda t + C \quad (16)$$

Now the probability to find one event in zero time must be zero, i.e., $P(1;0) = 0$ and therefore $C = 0$ and

$$P(1;t) - \lambda t e^{\lambda t} \quad (17)$$

this result can be generalized to arbitrary n by induction. then the probability to find n events in a time t is

$$P(n;t) = \frac{(\lambda t)^n}{n!} e^{-\lambda t} \quad (18)$$

3.0 Results and Discussion

3.1 Traffic Volume and Composition

The traffic volume data collected for the two locations MAR and COR for Monday is presented in Table 1.

Table 1

Traffic volume for MAR and COR on Monday

	MAR		COR	
Vehicle	Morning	Evening	Morning	Evening
Motorcycle	521	421	614	768
Tricycle	445	411	564	506
Passenger Cars	453	507	511	499
Bus/Pick Up	671	788	768	877
2-Axle	54	48	101	66
3-Axle	21	25	27	19
Total	2165	2200	2585	2735

The total number of vehicles counted for the MAR location for Monday morning and evening are 2165 and 2200 respectively. COR has 2585 and 2735 vehicles for morning and evening respectively. The percentage of tricycle counted in relation to the total vehicle counted for MAR and COR for morning and evening are 20.55%, 18.68%, 21.82% and 18.50% respectively. This is an indication that tricycle as a paratransit mode of transportation is responsible for moving a sizeable percentage of passengers on daily basis. Table contains the traffic volume for MAR and COR on Tuesday.

Table 2

Traffic volume for MAR and COR on Tuesday

	MAR		COR	
Vehicle	Morning	Evening	Morning	Morning
Motorcycle	256	324	321	312
Tricycle	345	397	456	399
Passenger Cars	413	312	389	461
Bus/Pick Up	912	819	445	687
2-Axle	47	61	55	49
3-Axle	18	21	25	29
Total	1991	1934	1691	1937

The percentage of tricycle counted on in relation to the total vehicle counted for MAR and COR for Tuesday morning and evening are 17.33%, 20.53%, 26.97% and 20.60% respectively. The traffic volume count for Wednesday is presented in Table 3.

Table 3

Traffic volume for MAR and COR on Wednesday

	MAR		COR	
Vehicle	Morning	Evening	Morning	Morning
Motorcycle	331	299	423	306
Tricycle	438	356	525	515
Passenger Cars	413	396	407	561
Bus/Pick Up	833	761	711	987
2-Axle	33	44	41	38
3-Axle	31	18	44	51
Total	2079	1874	2151	2458

The percentage of tricycle as compared with the total volume of vehicles counted indicated that MAR and COR are 21.07%, 19.00%, 24.41% and 20.95% respectively for Wednesday Morning and evening. The total volume of vehicle counted on Thursday is presented in Table 4.

Table 4

Traffic volume for MAR and COR on Thursday

	MAR		COR	
Vehicle	Morning	Evening	Morning	Morning
Motorcycle	294	244	311	334
Tricycle	349	315	431	419
Passenger Cars	290	219	318	305
Bus/Pick Up	654	876	908	843
2-Axle	12	18	77	81
3-Axle	22	9	40	51
Total	1621	1681	2085	2033

The result presented in Table 4 showed that the percentage of tricycle as compared with the total volume of vehicles counted indicated that MAR and COR are 21.53%, 18.74%, 20.67% and 20.61% respectively for Thursday morning and evening. The traffic volume for Friday is presented in Table 5.

Table 5

Traffic volume for MAR and COR on Friday

	MAR		COR	
Vehicle	Morning	Evening	Morning	Morning
Motorcycle	512	467	653	694
Tricycle	499	522	516	663
Passenger Cars	541	415	459	465
Bus/Pick Up	1324	1543	867	951
2-Axle	55	61	71	66
3-Axle	31	21	64	36
Total	2962	3029	2630	2875

From Table 5, the percentage of tricycles counted as compared with the total volume of vehicles counted indicated that MAR and COR are 16.85%, 17.23%, 19.62% and 23.06% respectively for Friday Morning and evening.

From the result of traffic volume count for the MAR and COR locations presented in Tables 1-5, it can be seen that the percentage of tricycles relative to the total number of vehicles counted ranges between 16.85% and 26.97%. This is an indication that tricycle as a paratransit mode of transportation constitutes a reasonable percentage of vehicle available to transport passengers on daily basis to and from the study locations.

3.2 Socio-Economic Data of Respondents

Slovin's formula and the 2006 census demographic data were used to determine the sample size of the study locations. The Population, population growth, calculated population in 2021 and the sample size calculated based on Slovin's formula are presented in Table 6.

Table 6

Determination of Sample size from Slovin's formula

Location	Local Government Area	Population in 2006	Population Growth Rate	Projected Population as at 2021	Error Margin	Sample Size Slovin's Formula
MAR	Ibadan North	432,900	3.5%	660,173	5%	400
COR	Ibadan South East	374,400	3.5%	570,960	5%	400

Based on the sample sizes calculated from Slovin's formula, 400 questionnaires were distributed at each study locations. The responses obtained from the well-structured questions designed to collect socio-economic data from commuters and tricycle riders is presented in Table 7.

Table 7

Responses from Commuters and Tricycle Riders.

S/N		Strongly Agree (%)	Agree (%)	Uncertain (%)	Disagree (%)	Strongly disagree (%)	Total (100%)
1	I have seen a tricycle before	70	20	6	2	2	100
2	I have used/entered a tricycle before	66	18	4	11	1	100
3	Tricycle is comfortable compared to other modes of transportation	45	27	3	2	23	100
4	Tricycle is cheap compared to other modes of transportation	43	16	15	22	4	100
5	Tricycle is fast compared to other modes of transportation	40	35	11	6	8	100
6	Tricycle is safe compared to other modes of	14	24	19	33	10	100

S/N		Strongly Agree (%)	Agree (%)	Uncertain (%)	Disagree (%)	Strongly disagree (%)	Total (100%)
	transportation						
7	Tricycle as a paratransit mode of transportation has reduced accident	37	23	6	11	23	100
8	Tricycle as a paratransit mode of transportation does not contribute to traffic congestion	15	29	13	18	25	100
9	Tricycle as a paratransit mode of transportation has provided a means of employment to people	56	24	2	6	12	100
10	The startup capital for tricycle is cheap compared to other mode of transportation	39	11	5	29	16	100
11	Tricycle as a paratransit mode of transportation is cheap compared to other modes of transportation	11	61	1	13	14	100
12	The maintenance cost of tricycle is cheap compared to other modes of transportation	48	21	7	22	2	100
13	Tricycle has functioned effectively as other major modes of transportation	64	18	2	12	4	100
14	Tricycle can be used to travel a long distance	21	11	23	12	33	100

From Table 7, a total of 90% of the respondents have seen a tricycle, 6% are uncertain to have seen a tricycle while a total of 4% have not seen a tricycle. A total of 72% agreed and strongly agreed that tricycle is convenient, 3% are uncertain while 25% disagreed that tricycle is convenient. Furthermore, 75% of the respondents agreed and strongly agreed that tricycle is fast, 11% are uncertain while 14% disagreed and strongly disagreed that tricycle is fast. A total of 72% agreed that tricycle is a cheap mode of transportation, 1% are uncertain while 27% disagreed that tricycle is a cheap mode of transportation. It can be deduced from the respondents that a high percentage of them agreed that tricycle as a paratransit mode of transportation is effective, cheap, fast and efficient and this further validate the earlier findings.

3.3 Poisson Distribution of Vehicle Inter-Arrival Time

The interarrival time of tricycles were measured to determine the rate of arrival and distribution at the study locations. The arrival time, observed frequency, theoretical or calculated frequency and Poisson distribution (probability of a time interval occurring) for COR and MAR from Monday to Friday were determined. Table 8 shows these typical data for MAR and COR on Monday

Table 8

Poisson Distribution of Inter-Arrival Time for MAR and COR on Monday.

MAR				**COR**			
Arrival Time (t) (minute)	Observed Frequency	P(t)	Theoretical Frequency	Arrival Time (t) (minute)	Observed Frequency	P(t)	Theoretical Frequency
1	4	0.0044	2.0	0	2	0.0011	0.45
2	5	0.0165	7.3	1	1	0.0073	3.00
3	20	0.0408	18.2	2	7	0.0249	10.23
4	41	0.0757	33.7	3	24	0.0568	23.34
5	41	0.1123	50.0	4	40	0.0972	39.95
6	74	0.1389	61.8	5	53	0.1332	54.75
7	61	0.1472	65.5	6	53	0.1520	62.47
8	67	0.1365	60.7	7	67	0.1488	61.16
9	44	0.1126	50.1	8	61	0.1274	52.36
10	32	0.0835	37.2	9	36	0.0969	39.83
11	31	0.0563	25.1	10	27	0.0664	27.29
12	12	0.0348	15.5	11	18	0.0414	17.02
13	6	0.0199	8.9	12	9	0.0236	9.70
14	2	0.0105	4.7	13	7	0.0124	5.10
15	3	0.0052	2.3	14	5	0.0061	2.51
16	2	0.0024	1.1	15	1	0.0028	1.15
	445	1.00	443.9		411	1.00	410.30

The interarrival time of tricycle observed for MAR and COR on Monday ranges between 1 and 16 minutes. The total tricycle observations for MAR is 445 and 411 was observed for COR. The tricycle arrival rate for MAR and COR are 27.81 and 25.69 respectively. The probability that 61 tricycles arrives in 7 minutes has the highest observed frequency with the probability of 14.72% for MAR while the probability that 53 tricycles arrives in 6 minutes has the highest observed frequency with the probability of 15.20% for COR.

Along with other similar data for Tuesday to Friday, the arrival rates of tricycles at the two study locations are increasing with a corresponding increase in their probability of arrival rates, this indicates that tricycles have been efficient with high arrival rates and corresponding high probability of occurrence. Therefore, tricycle as a paratransit mode of transportation has provided an alternative mode that is cheap, efficient and effective for the movement of both goods and commuters to and from the study locations. The Poisson probability distribution functions of MAR and COR from Monday to Friday are presented in Figures 2 and 3.

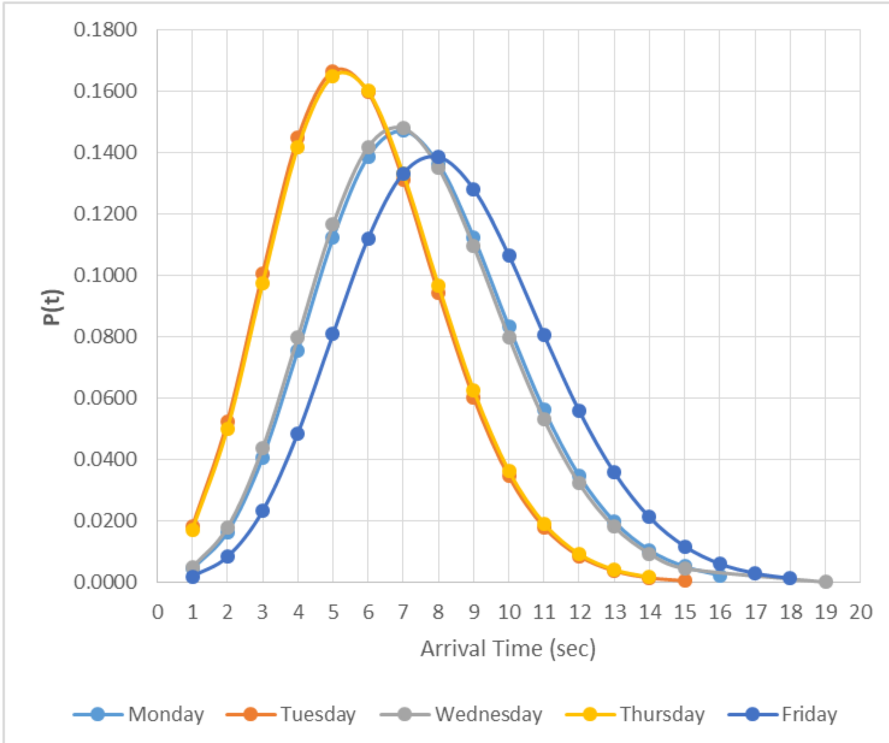

Figure 2: Poisson Distribution function for MAR.

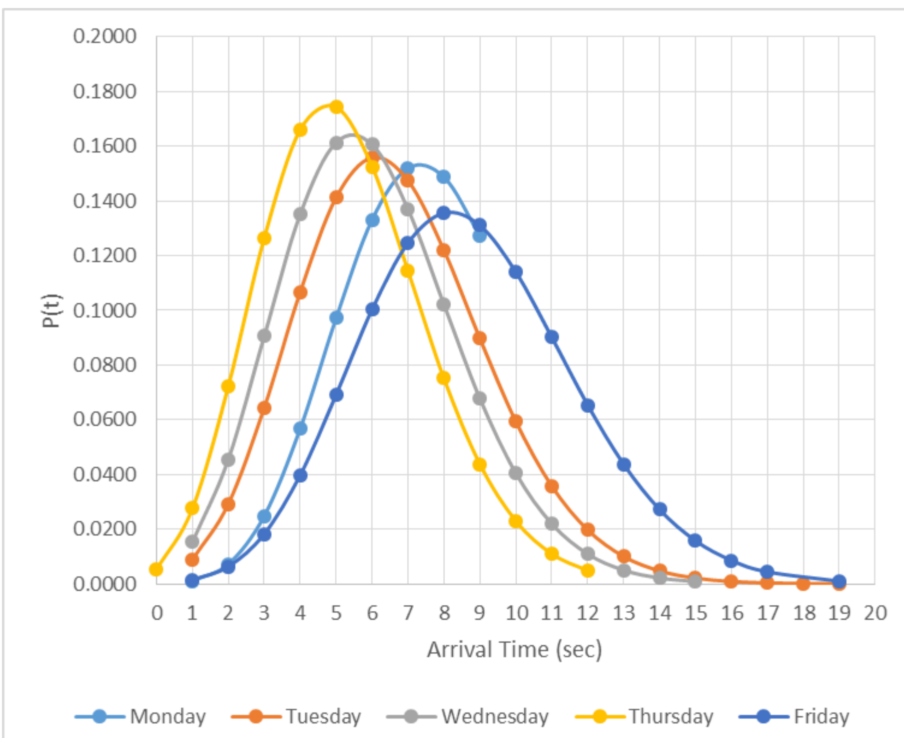

Figure 3: Poisson Distribution function for COR.

4.0 Conclusion

This research has focused on the stochastic analysis of the efficiency of tricycles as a public transportation mode in an urban city of Ibadan. Traffic volume and traffic composition data were collected at selected routes where the use of tricycles were prominent.

From this research, the percentage of tricycles compared to other modes of transportation is 16.85% and 26.97%. This affirms that the use of tricycle as a paratransit mode of transportation has increased in number and is acceptable to passengers. Tricycle occupancy measured ranged between 20% and 23% which affirmed that tricycles have been effective in moving a sizeable number of passengers and goods along the selected route. Respondents affirmed that tricycles have provided a cheap, effective and efficient alternative mode of transportation. The arrival rates of tricycles at the two study locations increases with a corresponding increase in the probability of arrival rates, this indicates that tricycles have been efficient with high arrival rates and correspondingly high probability of occurrence.

The use of tricycle has been effective and efficient as a paratransit mode of transportation, it is therefore recommended that government should monitor and regulate the activities of the tricycle operators. Adequate training should be given to the operators to boost their capacity. Special routes and parks should be created for tricycles where their operations will not interfere with the operations of other transportation modes and boost their service delivery.

References

[1] B. J. Zakari, „Planning for motorcycle transport in Katsina State, Nigeria. An unpublished undergraduate project in URP Department, Ahmadu Bello University, Zaria, 2005.

[2] A. S. Onawumi, E. B. Lucas, „Ergonomic Investigation of Occupational Drivers and Seat Design of Taxicabs in Nigeria. ARPN Journal of Science and Technology, vol. 2, no. 3, 2012, pp. 214-220.

[3] A. N. Ali, „Assessment of Passenger Satisfaction with Intra-City Public Bus Transport Services in Abuja Nigeria, Journal of Public Transportation, vol. 17, no. 1, 2014, pp. 99-119.

[4] S. B. Adejuyigbe, H. O. Adeyemi, „Ergonomics Assessment of Mass Transit Vehicles, Nigeria Journal of Engineering Management, vol. 1, no. 3, 2000, pp. 44-50.

[5] O. Ajayeoba, L. O. Adekoya, „ Evaluation of the Ergonomic Suitability of Passenger Seats in Molue Buses in Nigeria, Journal of Mechanical Engineering, vol. 1, no. 2, 2012, pp. 4-11.

[6] M. Judith, „Language, Communication on Wheels and National Development: The Inscriptions on Tricycle (Keke) Example, International Journal of English and Literature*,* vol. 4, no. 10, 2013, pp. 529-537.

[7] R. N. Obioma, C. C. Ibe, S. I. Ukaegbu, „Quality of the Paratransit Service (Tricycle) and its Operation in Aba, Nigeria: An Analysis of Customers' Opinions, Journal of Transport and Supply Chain Management, vol. 6, no. 1, 2012, pp. 262-276.

[8] A. Mukhtar, M. Waziri, B. Abdulsalam, and I. M. Dankani, „Assessment of Tricycle as a Tool of Poverty Alleviation in Maiduguri, Borno State, North-East Nigeria, IOSR Journal of Humanities and Social Science, vol. 20, no. 8, 2015, pp. 14-18.

[9] Sun, (2009) Saving the lives of tricycle users. http://www,sunnewsonline.com/webpage/abujareports/2009/May/04.abujareport-04-05-2009-002.htm. 2009, Accessed on: 29th May, 2021.

[10] F. Umrigar, P. K. Sikdar, K. Khanna, „Measuring the Effectiveness of the Urban Bus System in India Under Existing Organizational Set Ups. In PTRC: Urban Transport in Developing Countries, Lessons in Innovation, London, 1991, pp. 160–69.

[11] Y. Tanaboriboon, L. G. Madrona, „Silor Leks: A novel solution to the mobility problems in the developing countries – a case study in Bangkok. Land Transport and Development International Conference, Dunkirk, 18–22 June, 1990, pp. 347–352.

[12] A.B.F. Dourado, „Transporte 'Informal' X 'Formal' Verdaderia on Falsa Questao? Revista dos Transportes Publicos A, no. 17, 1995, pp.81–91.

[13] S. J. Park, Y. S. Lee, Y. E. Nahm, J. W. Lee, J. S. Kim, „Seating Physical Characteristics and Subjective Comfort: Design Considerations, SAE Technical Paper No. 980653, 1998.

[14] A. M. Miguel, M. G. Jesús, „Ergonomics of Urban Public Passengers Transportation, https://www.iienet2.org, 2004, Accessed on: 28th May, 2021.