International Journal of Innovative Mathematics, Statistics & Energy Policies 5(2):1-7, April-June, 2017

 www.seahipaj.org ISSN: 2467-852X

Statistical Analysis of Vehicular Traffic Count: A Case Study of Yola the Adamawa State Capital, Nigeria

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ABSTRACT
Vehicular traffic count data was collected at different locations in Yola, the Adamawa state capital of Nigeria. The study centred on assessing the contributions of the different means of road transportation to traffic hold-ups in the city centre. A two-way ANOVA is used compare the vehicular traffic count per vehicle type, per hour and per route. The result of the analysis reveals that there is a significant difference in the mean hourly vehicular traffic count per vehicle type per time of the day and per route. Post hoc test further reveals that the two- wheelers constitute about 52% of the total vehicles on the roads in Yola town, causing traffic jam in the city at rush hours of the day. The study recommended that mini- and midi- buses should rather be used for inter- city movements to reduce the traffic lock jam experienced during rush hours of the day.
Keywords: Vehicular traffic count, ANOVA, post hic test, two-wheeler.

1.0 INTRODUCTION

Transportation is about mobility of people, goods, animals and services from one place to another usually in a vehicle.

Transportation centrally affects the relationship between physical space and society, and changes in transportation affect the organization of human activity in urban and regional space. It structures the built environment, spurs urban growth, as well as orders relationships among cities in a national urban system (Yago, 1983).

As a matter of fact, world demand for transport services is growing at an alarming rate. For example, global demand for passenger transport service is predicted to grow from 26 trillion passenger kilometers in 1990 to 103 trillion passenger kilometers in 2050 on average (Schafer and Victor, 1997; USA DOT, 1999). Rapid and continued rise in housing and land prices are expected in cities with transportation

improvements and rapid economic and population growth (Goldberg, 1970); although with the increasing demand in transport comes an increased environmental pressure (atmospheric pollution, traffic accident, congestion, resources depletion, waste accumulation, disruption of nature etc.) hence the need to device a way of minimizing the environmental pressure.

Mode of transport is a term used to distinguish substantially different ways to perform transportation. The most dominant modes of transport are air, water, and land transport, which includes rail and road.

Road transport means movement of goods and personnel from one place to the other on roads. Road is a route between two destinations, which has been either paved or worked on to enable transportation by way of motorized and non-motorized carriages. Road can also be seen as an identifiable route of travel, usually surfaced with gravel, asphalt or concrete, and supporting land passage by foot or by a number of vehicles.

The most common road vehicle in the developed world is the automobile; a wheeled passenger vehicle that carries its own motor. As of 2002, there were 591 million automobiles worldwide. Other users of roads include motorcars, motorcycles, buses, trucks, bicycles and pedestrians.

Rajeswaran and Rajasekaran,(2014) in a study to model heterogeneous traffic at a congested place in Chennai using Cellular Automata (CA) and traffic simulator called VISSIM (Vissim is a microscopic multi-modal traffic flow simulation software package),concluded that there will be decrease in delay time and increase in maximum achievable velocity when there is reduction in 2W (Two Wheeler i.e motorcycles and bicycles) population. In fact, if no 2W is allowed then the delay time will be reduced to 70% and the maximum achievable velocity will be increased to 34%. Agunloye (2011) focused his study on the travels of public transport passengers' (road) from Ayangburen Taxi Park, Ikorodu, Lagos, Nigeria with primary aim of identifying its challenges and contributions to travel demand. The data types used was categorized based on routes, schedules, travel cost, number of vehicles, number of vehicles' daily travels, travel time, travel cost, travel length in temporal term, travel purpose, passengers' waiting time and travel frequency, unexpected breakdown, fuelling challenge, accidents, long journey time, frequent stops. The study then reveals that, the average age of passengers was 36 years, whose average annual income was about ₦15,000. The travel characteristics of passengers revealed that, average passengers' waiting time for cab was less than 15 minutes, the average travel frequency was 8 times per week, the average travel time was 45minutes, the temporal length of trip and waiting time (R^2= 30.1%) of respondents made significant contributions to the travel demands of the passengers in the study area. He concluded his study by saying that more cabs should be made available, fare subsidies and so on, in order to provide a more efficient public transport system in the study area.

2.0 METHODOLOGY

The data used in this study was obtained from the Nigerian Institute of Transport Technology (NITT), Zaria. The Institute carried out a national survey on transportation in the country in 2012 to determine the volume of vehicular traffic in major cities of the country.

2.1 Analysis of Variance (ANOVA)

According to Investopedia, ANOVA is an analysis tool used in statistics that splits the aggregate found inside a data set into two parts: systematic factors and random factors. The systematic factors have a statistical influence on the given data set, but the random factors do not. Analysis of variance is helpful for testing three or more variables. It is similar to multiple two-sample t-tests. However, it results in fewer type I error and is appropriate for a range of issues. **Study.com** defined ANOVA as a statistical procedure used to test the degree to which two or more groups vary or differ in an experiment. In most experiments, a great deal of variations usually indicates that there is a significant finding from the research, and in such case(s), ANOVA can be employed to test the degree of variations in the finding(s). In ANOVA, the judgment is based on either the p-value or the F-ratio (between) to the variance due to the error (within). The statistical model for a two-way ANOVA is given by:

$$x_{ij} = \mu + \alpha_i + \beta_j + \varepsilon_{ij} \quad \text{for i = 1, 2,…, k , j = 1,2, …, n} \quad \text{……..(1)}$$

where: μ = grand mean, α_i is the treatment effect, β_j *is* the block effect, ε_{ij} is the random error.

The total sum of variation(TSS) is usually partition into treatment sum of squares(SST), block sum of squares and residual sum of squares(SSE); i.e.

$$TSS = SST + SSB + SSE$$

where,

$$\text{TSS} = \sum_{i=1}^{k}\sum_{j=1}^{n}\left(x_{ij} - \bar{x}_{..}\right)^2 = \sum_{i=1}^{k}\sum_{j=1}^{n} x_{ij}^2 - \frac{x_{..}^2}{nk} \quad \ldots\ldots\ldots\ldots\ldots\ldots \quad (2)$$

$$\text{SST} = n\sum_{i=1}^{k}(x_{ij} - \bar{x}_{i.})^2 = \sum_{i=1}^{k}\frac{x_{i.}^2}{n} - \frac{x_{..}^2}{nk} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (3)$$

$$\text{SSB} = k\sum_{j=1}^{n}(x_{.j} - \bar{x}_{..})^2 = \sum_{j=1}^{n}\frac{x_{.j}^2}{k} - \frac{x_{..}^2}{nk} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (4)$$

and

$$SSE = TSS - SST - SSB \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots, \quad (5)$$

The analysis can be summarized in a tabular form thus:

Table 1: Two –Way ANOVA Summary Table

Sources	Sum of Squares (SS)	Degrees of Freedoms (DF)	Mean Squares (MS)	F_{com}
Treatment	SST	k-1	$S_1^2 = \frac{SST}{\mathrm{k}-1}$	$F_{com} = \frac{S_1^2}{S_3^2}$
Block	SSB	n-1	$S_2^2 = \frac{SSB}{(\mathrm{n}-1)}$	$F_{com1} = \frac{S_2^2}{S_3^2}$
Error	SSE	(n-1)	$S_3^2 = \frac{SSE}{\mathrm{k}(\mathrm{n}-1)}$	
Total	TSS	Nk-1		

From the table above, if F_{com} is greater than $F_{tab} = F_{\alpha\,[*,\ k(n-1)]}$; we reject the null hypothesis and conclude that there is no significant difference between the treatment means; otherwise, we fail to reject at α level of significance, * = treatment or block degrees of freedoms and k(n-1) = errors degree freedoms.

2.3 Application

The vehicular traffic count in Yola was categorized by NITT into vehicle type and according to the hour of the day; i.e. the data was collected on an hourly basis. Two-way ANOVA is used compare the vehicular traffic count per vehicle type, per hour and per route.

The null hypotheses are that there is no significant difference in the vehicular count per vehicle type, per time of the day, and per route, against the alternative hypotheses that there is a significant difference in the mean vehicular traffic count per vehicle type, per time of the day and per route.

The analysis in this paper was carried out at 5%level of significance using Statistical Software for Social Sciences (SPSS version22.0), Minitab and Excel.

3.0 RESULTS AND DISCUSSION

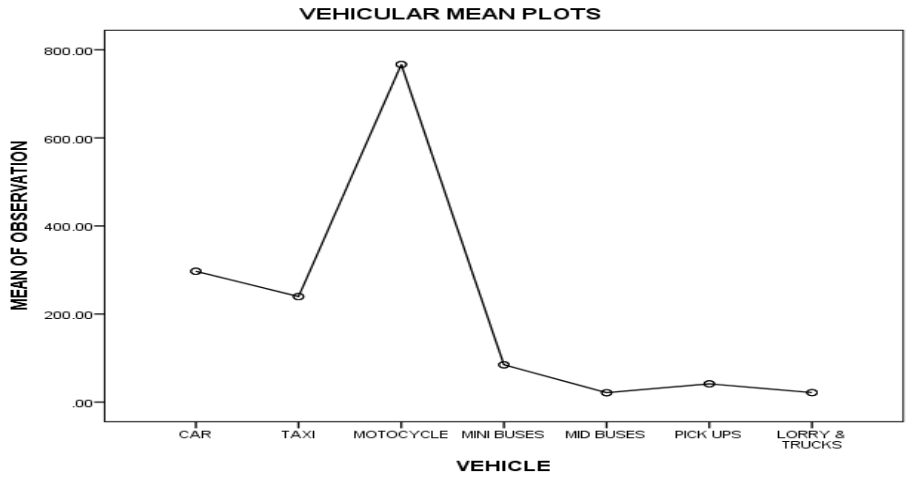

Figure 1 Vehicular Traffic Count

Figure 2 is a graphical display of the mean hourly vehicular count, showing the mean distribution of the different types of vehicles plying the routes. On the average, we have 767 Motorcycle, 297 Cars, 240 Taxis, 85 Minibuses, 42 pick-ups and 22 Lorries & Trucks and 21 Midi buses.

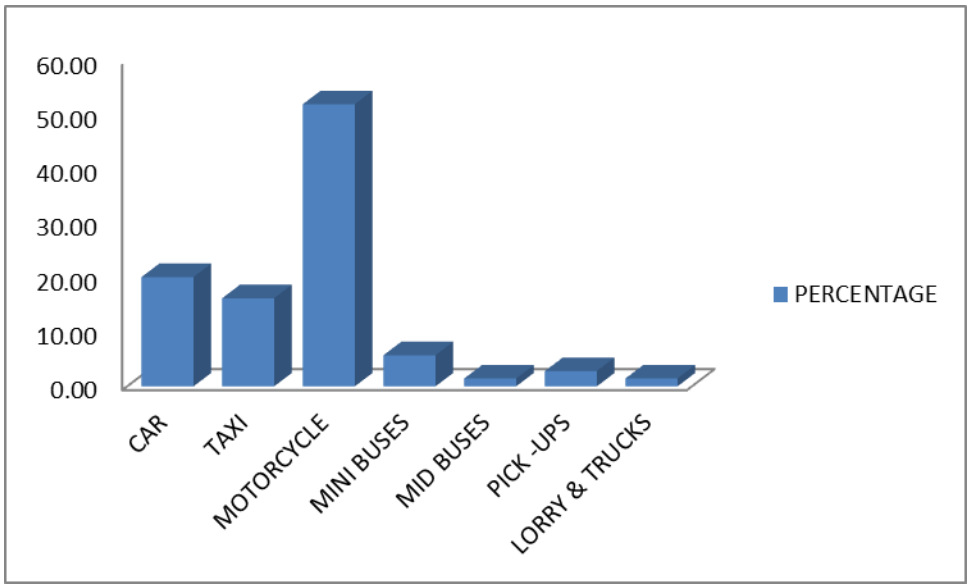

Figure 2: Bar chart of Percentage Vehicular Traffic Count

The figure above shows percentage distribution of the different types of vehicles. It reveals that there are more motorcycles (52.07%) followed by private cars (20.17%), then commercial cars {taxi} (16.27%) with the remaining vehicles constituting 11.49% of the total count.

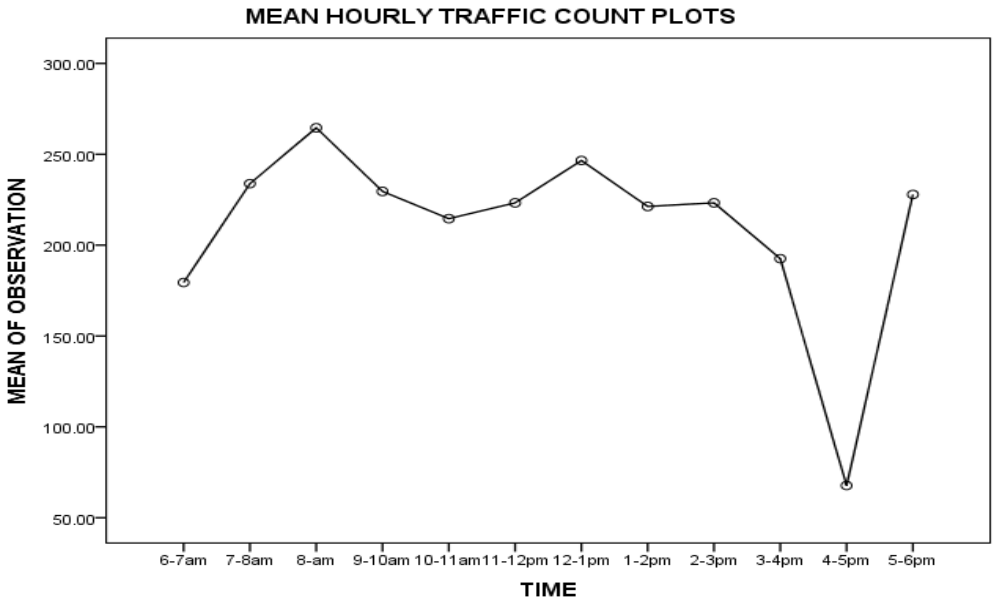

Figure 3: Mean Hourly Vehicular Traffic Count Plots.

The figure 3 above displays the mean hourly traffic count showing that the average number of vehicles on the routes is steady between the hours of 6 a.m. and 4 p. m, but drops drastically for an hour and rises sharply for another hour.

Table 2: Two-way ANOVA- Vehicle type and Time of the day

SOURCE	SS	DF	MS	F_{com}	p-value
Model	5396295.2	17	317429.3	39.787	.000
Time	192988.1	11	17544.372	2.199	.025
Vehicle type	5203307.1	6	867217.857	108.697	.000
Error	526566.7	66	7978.281		
Total	5922861.8	83			

Table 2 displays the ANOVA result, with $p = 0.000 < 0.05$ for vehicle type, hence we reject the null hypothesis and conclude that there is a significant difference in the mean vehicular traffic count at 5% level of significance. This implies that the mean numbers of vehicle types plying the various routes are not the same.

A post hoc analysis reveals that there is a significant difference between motorcycle and all other possible pairwise comparisons.

Also, from table 2 above; since $p = 0.025 < 0.05$ for time of count, shows that the mean hourly traffic count differs statistically per hour at 5% level of significance. Further analysis shows that there is a significant difference between the mean hourly traffic count in the time range 4-5pm with any other time ranges.

TABLE 3: Two-way ANOVA- Route /Time of the day

SOURCE	SS	DF	MS	F_{com}	*P-value*
Model	10370578.33	14	740755.60	5.95	.00
Route	3255851.33	3	1085283.78	8.70	.00
Time	7114727.00	11	646793.36	5.11	.00
Error	4111935.67	33	124604.11		
Total	14482514.00	47			

From the table above, since the $p < 0.05$ for both Route and Time, we reject the null hypothesis of no difference and conclude that the vehicular volume differs at various routes and at different time of the day at 5% level of significance. The post hoc test results reveals that the traffic flows in Atiku Abubakar Way, Jemeta-Yola Road and Numan Road have seemly the same traffic flow while the traffic condition along Mohammed Mustapha Way differs significantly from the other three routes. Also, the traffic flow fluctuate greatly within the day, with minimum traffic inflow between 8-9am and a maximum outflow between 4-5pm when people are all struggling to go to work/return home.

Table 4: Two-way ANOVA- Route/Vehicle type

SOURCE	SS	DF	MS	F_{com}	*P-value*
Model	272001658.89	9	30222406.54	21.96	.00
Route	3426966.96	3	1142322.32	.83	.50
Vehicle	268574691.93	6	44762448.65	32.53	.00
Error	24771405.79	18	1376189.21		
Total	296773064.68	27			

From table 4 above, since $p < 0.05$ for vehicle type, we reject the hypothesis of no difference and conclude that the mean vehicular count differs per vehicle type. However, there is no significant

difference in the mean vehicular count in the four routes. Post hoc reveals that there are more of motorcycles on the routes followed by private cars and each differs greatly with the other vehicle type.

3.3 CONCLUSION

Summarily, this study was carried out solely to investigate the vehicular traffic count on the Nigerian roads in the north eastern part of the country, using Yola, the Adamawa state capital as the case study area. The data was obtained from the Nigerian Institute of Transport Technology, Zaria.

The result of the analysis reveals that there is a significant difference in the mean hourly vehicular traffic count per vehicle type per time of the day and per route. Post hoc test further reveals that the two-wheelers constitute about 52% of the total vehicles on the roads in Yola town, causing traffic jam in the city at rush hours of the day.

The study therefore recommends that:

i. There should be few or no 2-wheel vehicles on the roads. However if the two-wheeler must operate, then there should be restrictions as to the time of their operations. This is necessary to ease up the congestions and traffic "Jam" they often cause.
ii. Mini and midi buses should rather be used for inter- city movements to reduce the traffic lock jam experienced during rush hours of the day.
iii. The government should set up a vibrant transport management system that will be saddled with the responsibility of constantly carrying out research on the most effective and efficient way of improving the traffic flow and hence improving the productivity of the citizenry and improving the economy of the nation at large.
iv. The Government should diversify the land mode of transportation by introducing rail system of transportation for town services to ease up congestion on our roads.

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