ISSN 0024-9521
IJG Vol. 41, No. 1, June 2009 (53 - 70)


INDONESIAN JOURNAL OF GEOGRAPHY

# FLOW PATTERNS OF VEHICULAR TRAFFIC ALONG HIGHWAY TOLL PLAZA IN OGUN STATE

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## ABSTRACT

*Congestion on our highways, freeways and arterials are increasing at an alarming rate. This occurs because there is an increase in vehicular growth without a corresponding increase in road size, and this has made free flow of traffic a preponderant problem in our highways. Toll plaza causes delay on our highways and results are formation of queue. This paper examined how simple queuing model can be used to determine traffic intensity and the flow pattern of car traffic at a toll plaza. The study was carried out with twelve field assistants at Ogere toll plaza in Ogun State. Findings show a significant variation in the degree of hourly traffic intensities at the four pay points for cars at the toll plaza. However, variation in the daily traffic intensities at the four pay points for cars showed no significant variation. The study also revealed that bumps constructed to check vehicles speed, hawker's trading activities are among other factors that constitute hindrance to free flow of traffic other than service time and inter-arrival time of cars at the toll plaza. It is therefore recommended that appropriate authority should look into these factors and take necessary steps towards ensuring free flow of traffic at the plaza.*

**Key words:** flow pattern, vehicular traffic, toll plaza

## INTRODUCTION

Congestion on our highways, freeways and arterials is increasing at an alarming rate. This can be attributed to an increase in the fleet of vehicle in the country. For instance, the number of vehicle registered in the country was 195, 000 in 1975, rose steadily to 615,556 in 1985, but declined to 218,726 in 1995 [*World Bank,* 1990; *FOS,* 1987; *FOS,* 1997]. In recent times, congestion has been further compounded by the sudden increase in the level of motorization between year 2000 and 2002. In 1995, 51,000 vehicles were added to the existing vehicle fleet in the country; which decreased to 10,947 in 1997 but rose to 83,406 in 2000. Surprisingly, and over 200,000 vehicles were officially registered as cars, buses, Lorries and others. In a way, the increase between 1999 and 2001 of vehicle fleet is 363 percent [*Adeniji,* 2000; *Oyesiku,* 2002]. This increase in the percentage of fleet of vehicles invariably may increase road traffic accidents, pollution, vehicle operating costs and more importantly undesired long delays.

Delay is a temporary hold up cause by one vehicle to the other; usually attributed to traffic activities in different parts of the city and the country at large. Therefore, understanding traffic delay and the solutions to it, requires the knowledge of the basic theoretical construct of delay, which is the queuing model. Therefore, for anything that moves electrically, there is bound to be delay and the delay will form a queue [*Oyesiku,* 2002; *Raji,* 2003; 2007].

The practical purpose of queuing model is to provide examination tools for systems composed of queues leading to service facilities to be more efficient. Mathematically, these models deal with both regularities and irregularities of the system - ultimately identifying occurrence of congestion (resulting from irregularities) and offering avenues for improving efficiency, as well as producing specific numerical data for further application [*Beasley,* 2002].

Numerous traffic models have been developed to: focus and stimulate traffic; emulate real time traffic conditions, evaluate and determine traffic operations; provide a detailed analysis of proposed designs and operational improvements; and optimize signal timing by developing signal timing plans to improve traffic flow on arterials and networks and to reduce unnecessary fuel consumption and delay as well [*FHA,* 2001].

In spite of the numerous models focusing on delay, queuing model in general has not been subjected to extensive empirical analysis of vehicular flow pattern in Nigeria. As a result of this, the application and relevance of the model is not properly understood. However, considering the significance of time in trip generation and travels, the model can be used to predict the flow pattern of vehicular traffic at the toll plaza.

The responsibilities of road system are shared between the three levels of government with the Federal Government responsible for the following classes of road [*FMT,* 1993].

1. Inter-State roads connecting two or more States.
2. International roads serving as connecting links between Nigerian and her neighbors and forming parts of the African international highways system namely.
3. Trans Saharan Highways (Lagos Kongolam Algiers).

4. Trans - Central African Highways (Lagos - Mombasa).
5. Trans - West African Highways (Inland route).
6. Dakar - Jibiya - Ganboru - Ndjamena, and (v) Trans - West African Highways, Coastal route (Novakehott - Semi Podgi - Lagos).

Of all the 32,000 kilometer Federal Highways, the study area (Lagos - Ibadan Highway) falls into the two classes, first, as Inter-State roads connecting three states (Lagos, Ogun and Oyo) and second, as international route connecting Nigeria and her neighbours. It has a distance of over 100 kilometres from Berger in Lagos to Ojoo in Ibadan.

There are many highways in Nigeria but Lagos-Ibadan and Sagamu-Benin were the two highways initially chosen for the research. But due to logistic problems, Lagos-Ibadan Highway was later chosen. The choice of Lagos-Ibadan highway as the study area can be attributed to volume of vehicular traffic it commands (see Table 1) over Benin-Sagamu highway. At inception, a toll plaza was erected at the end of Lagos highway but was later removed. As at the time of the study, there are two erected toll plaza along the Lagos – Ibadan highway. The first toll plaza is located at Ogere in Ikenne Local government of Ogun State when driving on Lagos - Ibadan direction of the highway. The second toll plaza is located at Oluyole Local government area of Oyo State.

Table1. The number of Light Vehicles passing through Lagos –Ibadan and Lagos- Benin Highways from 1st to 7th December, 2002

| | Ilese toll plaza | | Sagamu toll plaza | | Ogere toll plaza | |
|---|---|---|---|---|---|---|
| | Lagos-Benin | Benin-Lagos | Lagos-Benin | Benin-Lagos | Lagos-Ibadan | Ibadan-Lagos |
| Sunday | 1865 | 2019 | 2008 | 3699 | *3087 | *5176 |
| Monday | 1502 | 1604 | 2670 | 2387 | *3457 | *3687 |
| Tuesday | 1725 | 1535 | 2703 | 2312 | *3783 | *3687 |
| Wednesday | 1613 | 1359 | 2422 | 2430 | *3391 | *3505 |
| Thursday | 1030 | 1236 | 3232 | 2580 | *4525 | *3402 |
| Friday | 1324 | 1519 | 5796 | 5323 | *8114 | *3611 |
| Saturday | 2488 | 1387 | 4838 | 4106 | *6774 | *7454 |

Source: Extracted from Records Obtained from Authorities of the toll Plaza by the Authors, 2003.

However, Ogere toll plaza was chosen as the study site. The choice of Ogere toll plaza as a study site over Ibadan end of the toll plaza can be attributed to the number of traffic it commands (see table1). Besides, the location of the toll plaza is strategic. Leaving Lagos - Benin by pass at Sagamu interchange, there is only one outlet before getting to the toll plaza. At Ibadan - Lagos direction of the highway, a similar situation is observed. At the toll plaza, vehicle plying the routes are classified into three categories and these include:

1. Heavy vehicle

2. Medium vehicle
3. Light vehicle

Heavy vehicle consist of trailers, luxurious buses, caterpillar, Lorries and other vehicle above five tones. Medium vehicle comprises buses, pick-ups, coasters and light vehicle comprises of cars and other vehicles not as big as buses and pick-ups. In this study, the focus is basically on cars and this falls in the third category of these classifications. These cars include Jeeps, Saloon and Wagon cars be it private, commercial or public.

Also at Ogere toll plaza, workers manning the booths engage in three types of shift. These include (i) Morning shift, (ii) Afternoon shift and (iii) Night shift. Morning shift is between (7am - 2pm), Afternoon shift lies between (2pm - 7pm) and Night shift starts from (7pm - 7am). It is based on these shifts that we selected 7am – 7pm for the study.

## THE METHODS

### Pilot Study

A reconnaissance survey was carried out on the choice of toll plaza and facts about existing traffic situation were collected. Based on the pilot survey and available records at toll plaza, Monday, Tuesday, Friday and Saturday of the week were picked for the proper survey. However, we tagged these days Day 1, Day 2, Day 3 and Day 4. The pilot study also enhanced the approval of the days picked by the management of the toll plaza. The survey also helped in identifying variables such as service time, queue length at service, arrival time and inter arrival time, queue length at arrival and jockeying of cars at the toll plaza. For each day, recording was supposed to last for twelve hours (l2hrs) that is 7am-7pm, but available records and the pilot study show that the volume of vehicles arriving at the toll plaza is momentous around 8 am. Hence, an eleven hour period of 8am - 7pm was used. At the toll plaza, there are four pay points for cars tagged box 5, box 6, box 7 and box 8 which we tagged pay point 1, pay point 2, pay point 3 and pay point 4 respectively. Pay point 1 and pay point 2 represent pay points for cars on Ibadan - Lagos side of the highway while pay point 3 and pay point 4 represent pay points for cars on Lagos - Ibadan side of the highway.

### Data Gathering Procedure

Cars arrive at the toll plaza continually; but not at the same time and pace. Therefore, the arrival of cars in time $t_0$, $t_1$, $t_2$, …$t_n$ do not correspond to $t_0 = t_1 = t_2 = t_n$ or $t_1 - t_0 = t_2 - t_1$ etc, and this makes the arrival cars to be continual but at random. Therefore, random arrival of cars, arrival time, inter-arrival time, service time, queue length at arrival, queue length at service and jockeying of cars were observed and recorded in the data sheet.

Twelve field assistants were used instead of eight during the pilot survey. In the pilot survey, two field assistants manned each of the four pay points at the toll plaza and this led to a total of eight field assistants. During recording, it was observed that a field assistant cannot handle observation and the recording of service time, queue length at service and jockeying of cars simultaneously, it then required the use of two field assistants, one observing and dictating, and the other field assistant doing the recording. The third field assistant was responsible for the recording of arrival time, queue length at arrival time and inter arrival time.

**Vehicular Traffic Flow at the Toll Plaza**

In analyzing and describing the results, it is important to interpret traffic intensities. Traffic intensity serves as a measure of congestion at the toll plaza, and rate of congestion determines the flow of vehicles. *Beasley* [2002] suggested that if traffic intensity tends to zero, there is very little queue and there is also a free flow of vehicles. But when traffic intensity tends to move toward one it means that queue increases and there is no free flow of vehicles. Therefore, when $\rho \leq 0$ it implies very little queue/free flow and when $0 < \rho \geq 1$ it means that queue increases which translates to congestion and no free flow. It is on this basis that results obtained are interpreted. In determining traffic intensity [*Stevenson,* 1999; *Barry* and *Stair Jr.*, 1982; *Lucey,* 1988], gave this formula:

$$\rho = \frac{Average\_arrival\_rate}{Average\_service\_rate} = \frac{\lambda}{\mu} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (1)$$

Where

$\rho$ = Traffic Intensity

$\lambda$ = Average Arrival Rate

$\mu$ = Average Service Rate

*Lucey* [1988] went further to explain that on occasions the arrival and service speeds are expressed differently. For example, the average time between arrivals is 4 minutes and the average service time is 3 minutes, which is the case in our study, then the formula in (1) may not be applicable. To determine the traffic intensity $\rho$ he came up with this formula:

$$\rho = \frac{Average\_service\_time}{Average\_inter-arrival\_rate} = \frac{\lambda_1}{\mu_1} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (2)$$

Where

$\rho$ = Traffic Intensities

$\lambda_1$ = Average Service Time

$\mu_1$ = Average Inter – arrival Rate

We also observed that the arrival pattern of cars followed a timely spaced time sequence of Poisson process as shown in figure 1 such that the Poisson properties is observed

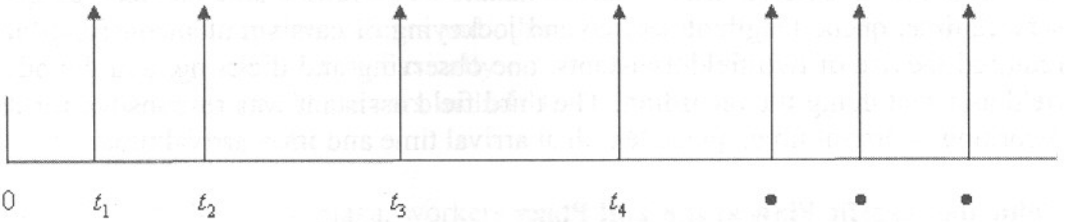


Figure 1. A timely spaced time sequence of poison process

Length of cars at time $(t)$, with rate $(\lambda_t)$ being average inter- arrival of cars per unit of time (over a long period of time), follows that: for probability of $(n)$ arrival of cars at $(t)$ unit of time is given by

$$P_n(t) = \frac{(\lambda_t t)^n}{n!} e^{\lambda_t t} \quad \text{.......................................(3)}$$

Therefore, the derived values for hourly and daily traffic intensities are shown on Table 2 and Table 3. This section therefore discusses hourly and daily variation in the traffic intensities at the four pay points under study.

**Hourly Variations of Traffic Intensities**

As shown on Table 2, the highest traffic intensities at Pay Point 1 in day 1 was recorded between (8am - 10am) and the lowest was recorded between (6pm to 7pm). Generally, there is a decrease in traffic intensities from (8am - 7pm). At Pay Point 2, the case was reversed because while the highest traffic intensity was observed between (6pm - 7pm), the lowest value was recorded between (9am - 10am). At Pay Point 3, the highest traffic intensity was observed between (10am - 11am) with the lowest value recorded between (8am - 9am). The highest traffic intensity at Pay Point 4 was recorded between (9am - l0am) followed by 0.165 that was recorded between (11 am and 12 noon). The lowest traffic intensity at this Pay point was recorded between (6pm and 7pm) with a value of 0.060, a replica of Pay point 1. From the analysis, it is clear that the lowest traffic intensity for day 1 lies between (6pm and 7pm) except for Pay Point 2 and Pay Point 3 where the highest value lies between (6pm and 7pm) and the lowest figures lie between (8am and 9am).

On day 2, Pay Point 1 had the highest value of traffic intensity (0.134), and it occurs between (5pm and 6pm) followed by (0.124) traffic intensity that falls between (6pm and 7pm). However, (0.070) represents the lowest traffic intensity at the Pay Point. At Pay Point 2 the highest traffic intensity is (0.160) and it occurs between (2pm and 3pm) and the lowest traffic intensity occurs between (8am and 9am) with a value of (0.075). Pay Point 3 traffic intensity was at its highest between (12pm and 1pm) with a value of (0.321). At the same point, the lowest traffic intensity has a value of (0.076). Pay Point 4 on the other hand, has the highest value (0.225) between (9am and 10am) and the lowest traffic intensity (0.110) occurring between (5pm and 6pm).

Table 2: Summary of Hourly Traffic Intensities of Cars at the Toll Plaza from Day One to Day Four

| | | DAY 1 | | | | DAY 2 | | | |
|---|---|---|---|---|---|---|---|---|---|
| S/N | HRS am-pm | Pay point 1 | Pay point 2 | Pay point 3 | Pay point 4 | Pay point 1 | Pay point 2 | Pay point 3 | Pay point 4 |
| 1 | 8-9 | 0.1116 | 0.1043 | 0.1289 | 0.1489 | 0.1041 | 0.0747 | 0.2032 | 0.1637 |
| 2 | 9-10 | 0.1031 | 0.0883 | 0.2018 | 0.1797 | 0.1109 | 0.1176 | 0.2068 | 0.2251 |
| 3 | 10-11 | 0.0723 | 0.1102 | 0.2562 | 0.1328 | 0.0929 | 0.1126 | 0.1406 | 0.1749 |
| 4 | 11-12 | 0.0706 | 0.1011 | 0.1530 | 0.1652 | 0.0914 | 0.1124 | 0.2281 | 0.1464 |
| 5 | 12-1 | 0.0742 | 0.1091 | 0.1929 | 0.1325 | 0.0949 | 0.1016 | 0.3210 | 0.1347 |
| 6 | 1-2 | 0.0542 | 0.1097 | 0.1715 | 0.1005 | 0.0700 | 0.1500 | 0.2442 | 0.1706 |
| 7 | 2-3 | 0.0558 | 0.1097 | 0.1731 | 0.0952 | 0.0729 | 0.1600 | 0.1645 | 0.1725 |
| 8 | 3-4 | 0.0661 | 0.1345 | 0.1691 | 0.1331 | 0.0734 | 0.1462 | 0.1494 | 0.1256 |
| 9 | 4-5 | 0.0691 | 0.1524 | 0.1400 | 0.1019 | 0.0895 | 0.1033 | 0.1401 | 0.1262 |
| 10 | 5-6 | 0.0596 | 0.1572 | 0.1443 | 0.1244 | 0.1343 | 0.1054 | 0.1914 | 0.1104 |
| 11 | 6-7 | 0.0410 | 0.1862 | 0.1330 | 0.0603 | 0.1237 | 0.0943 | 0.0761 | 0.0999 |

| | | DAY 3 | | | | DAY 4 | | | |
|---|---|---|---|---|---|---|---|---|---|
| | HRS am-pm | Pay point 1 | Pay point 2 | Pay point 3 | Pay point 4 | Pay point 1 | Pay point 2 | Pay point 3 | Pay point 4 |
| 1 | 8-9 | 0.0616 | 0.1066 | 0.1606 | 0.1633 | 0.0616 | 0.1066 | 0.1606 | 0.1633 |
| 2 | 9-10 | 0.0956 | 0.1618 | 0.1910 | 0.1527 | 0.0956 | 0.1618 | 0.1910 | 0.1527 |
| 3 | 10-11 | 0.0839 | 0.2078 | 0.2740 | 0.1973 | 0.0839 | 0.2078 | 0.2740 | 0.1973 |
| 4 | 11-12 | 0.0888 | 0.1916 | 0.2299 | 0.2058 | 0.0888 | 0.1916 | 0.2299 | 0.2058 |
| 5 | 12-1 | 0.0732 | 0.1365 | 0.3280 | 0.2685 | 0.0732 | 0.1365 | 0.3280 | 0.2685 |
| 6 | 1-2 | 0.0884 | 0.1855 | 0.2935 | 0.2140 | 0.0884 | 0.1855 | 0.2935 | 0.2140 |
| 7 | 2-3 | 0.0993 | 0.2916 | 0.2730 | 0.3068 | 0.0993 | 0.2916 | 0.2730 | 0.3068 |
| 8 | 3-4 | 0.0810 | 0.2362 | 0.2821 | 0.2279 | 0.0810 | 0.2362 | 0.2821 | 0.2279 |
| 9 | 4-5 | 0.1351 | 0.2606 | 0.2516 | 0.3185 | 0.1351 | 0.2606 | 0.2516 | 0.3185 |
| 10 | 5-6 | 0.0892 | 0.2593 | 0.3349 | 0.1604 | 0.0892 | 0.2593 | 0.3349 | 0.1604 |
| 11 | 6-7 | 0.0906 | 0.1813 | 0.2762 | 0.2166 | 0.0906 | 0.1813 | 0.2762 | 0.2166 |

Source: Authors' Field Survey, 2003

On day 3, Pay Point 1 had the lowest traffic intensity of (0.062), and this was recorded between (8am and 9am) followed by value of (0.073) that occurs between (12pm and 1 pm). The highest value (0.135) as shown in the Table 2 was recorded between (4pm and 5pm). Pay Point 2 was recorded between (2pm and

3pm) with the highest traffic intensity of (0.292) followed by (0.261) that falls between (4pm and 5pm). The lowest traffic intensity of the Pay Point occurs between (8am and 9am) with value of (0.107). A look at Pay Point 3 shows the lowest traffic intensity value of (0.161) between (8am and 9am) and the highest traffic intensity (0.335) between (5pm and 6pm). On table 2 Pay Point 4 has (0.139) as the highest traffic intensity and it was recorded between (4pm and 5 pm) followed by (0.307) was recorded between (2pm and 3pm). The lowest value of traffic intensity at Pay Point 4 is (0.153) which was recorded between (9am and 10am).

On day four, the highest traffic intensity at Pay Point 1 was recorded between (4pm and 7pm) with value of (0.279) and the lowest traffic intensity for the same pay point has a value of (0.115), and was recorded between (8am and 9am). At pay point 2, the highest traffic intensity was recorded from the 10th row, between (5pm and 6pm) with value of ( 0.237), and the lowest value was recorded from the 7$^{th}$ row with value of (0.105). As shown on table 2, the highest traffic intensity at Pay Point 3 was recorded from the fourth row between (11am and 12 pm), and the lowest was recorded from the 11$^{th}$ row with values of (0.336) and (0.180) respectively. Pay Point 4's highest traffic intensity of (0.368) and the lowest (0.177) were recorded between (9am and 10am) and (6pm and 7pm) respectively.

**Daily Variations of Traffic Intensities and Volume of Traffic**

Table 3 shows the number of cars and traffic intensities at the four pay points. Figure 2 on the other hand illustrates variations in the volume of cars re-corded at the four pay points. As shown on table 3, the highest traffic intensity was recorded at pay point 3 in day 1 and incidentally, pay point 3 has the highest volume of traffic. Interestingly, the results for day3 and day 4 were similar to day 1 except day 2 where the highest traffic intensity was recorded at pay point 3 with pay point 2 having the highest volume of traffic. These results clearly show that on day 1, day 3 and day 4, long queue formed at pay point 3 and the traffic situation at the pay points did not reflect free flow.

On day 2, the situation at pay point 3 in terms of queuing and traffic flow remains the same. As shown on Figure 2, the highest traffic volume on day 1 (1,667), day 3 (2,632) and day 4 (3164) can be found at pay point 3.The question that comes to mind was that:(i) could it be that the same individual was handling the pay point for the days under study, (ii) could it be that the service time at pay point 3 was greater than the arrival pattern of cars? , and (iii) What is responsible for this pattern of traffic volume at pay point 3?. In proffering answers to these questions, we observed that different individuals manned the toll booth and that the highest traffic volume particularly for cars was recorded in Lagos–Ibadan direction of the highway. Also, the toll plaza was designed in a way that would make it easier for cars arriving at the plaza to keep to left and drive towards the first toll point which is pay point 3.Generally, we observed that there were other factors that lead to long queue formation and as well hinder free flow other than the time each car was being attended. These factors are discussed under pattern of traffic flow at the toll plaza in the next section.

Table 3: Daily Traffic Intensities at the four Pay Points

| | Day 1 | | Day 2 | | Day 3 | | Day 4 | |
|---|---|---|---|---|---|---|---|---|
| Pay points | No of cars | Traffic intensities | No of cars | Traffic intensities | No of cars | Traffic intensities | No of cars | Traffic intensities |
| 1 | 1169 | 0.072 | 1066 | 0.096 | 1105 | 0.09 | 1599 | 0.183 |
| 2 | 1196 | 0.121 | 1727 | 0.116 | 1779 | 0.202 | 2368 | 0.175 |
| 3 | 1667 | 0.171 | 1583 | 0.188 | 2632 | 0.263 | 3164 | 0.277 |
| 4 | 956 | 0.126 | 1131 | 0.15 | 1761 | 0.221 | 1955 | 0.193 |

Source: [*Authors' Field Survey*, 2003]

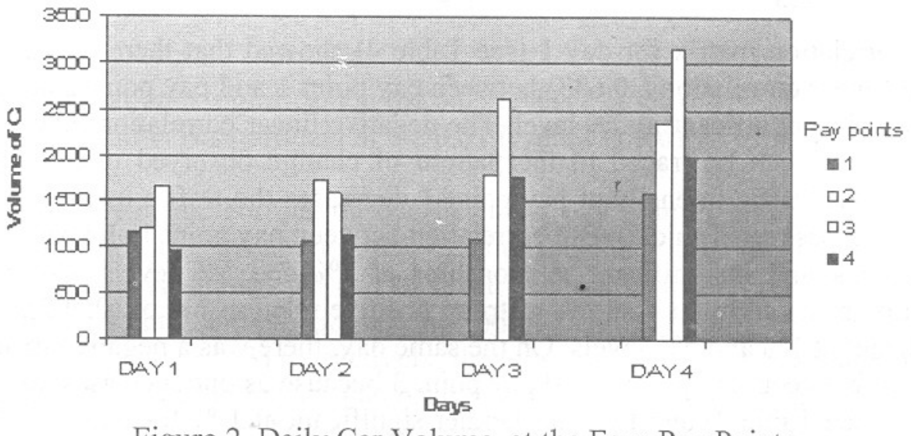


Figure 2. Daily Car Volume at the Four Pay Points

## RESULTS AND DISCUSSION

### Correlation Results

This section discusses analysis of the correlation of traffic intensities between the pay points as shown in zero order matrix (see Table 4), and explains the results of the set hypotheses as well. Due to variations in syntax of the interpretation of correlation coefficients as documented in the literature, it is therefore significant to draw attention to the possible limits of correlation coefficient in this study. *Mason et al.* [2003] observed that a coefficient of correlation $r$ close to 0 (say, 0.08) shows that the relationship is quite weak and the same conclusion is drawn for r = -0.08. Coefficients of -0.91 and + 0.91 have equal strength (Strong relationship). They went further to establish that the strength of the correlation did not depend on the direction (either - or +), and hence, they gave the following summary in figure 3. Therefore, the interpretation of the correlation results of the study will be based on the summary of *Mason et al.* [2003].

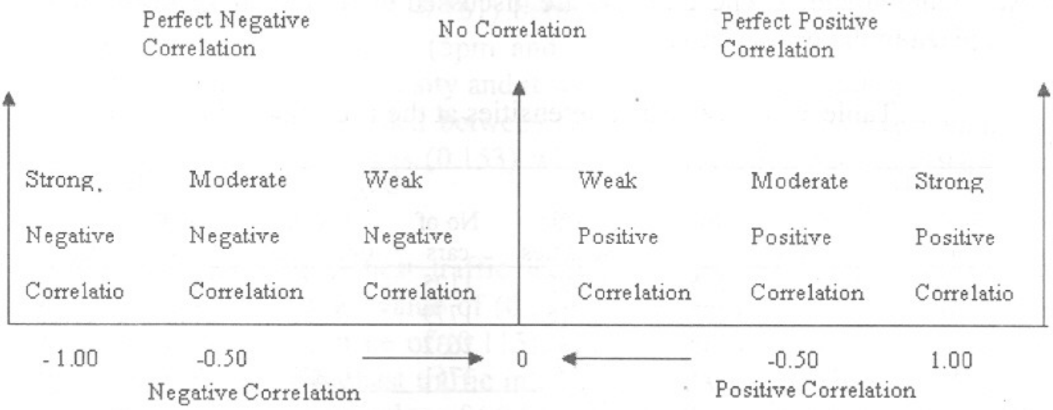


Figure 3. Summary of possible limits of correlation coefficients

Correlation matrix for day 1 (see Table 4) showed that there was a strong negative Linear correlation (-0.633) between pay point 1 and pay point 2 at the toll plaza, and also significant at 5% level. The negative linear correlation between the two pay points can be traced to the pattern of change observed in their traffic intensities. As traffic intensity at pay point 1 decreases the traffic intensity at pay point 2 increases (see Table 2). But correlation between pay point 1 and pay point 3 showed weak and insignificant relationships at 1% and 5% levels. Correlation between point 1 and point 4 shows a strong positive relationship of (0.792), which is significant at 1% and 5% levels. On the same day, there was a negative moderate correlation between pay point 2 and pay point 3 because as one increases, the other decreases (see Table 2) and they are neither significant at 1 % level nor 5% level. Between pay point 2 and pay point 4, there was negatively strong correlation of (-0.730) which was significant at 5% level. Correlation between pay point 3 and pay point 4 is (0.306), which showed a weak relationship.

As shown on (Table 4), correlation matrix for day 2 revealed that the correlation coefficient between pay point 1 and pay point 2 is (-0.703). The result shows a negatively strong relationship between the two pay points and also significant at 5% level. The negative relationship between the two pay points can also be attributed to the fact that, as traffic intensities of pay point 1 decrease, there is an increase in traffic intensities at pay point 2 (see Table 2). Between pay point 1 and pay point 3 there is a negatively weak correlation of (-0.184). The negative relationship between the two pay points can be attributed to the mixed observation in the increase and decrease in their traffic intensities (see Table 2). Similarly, there is a negatively weak relationship of (-0.278) between pay point 1 and pay point 4. Between pay point 2 and pay point 3, and pay point 2 and pay point 4, there is a weak positive correlation with values (0.013) and (0.266) respectively. The relationship between pay point 3 and pay point 4 is positively weak with correlation coefficient of (0.276).

Table 4. Correlation matrix between pay poin and day

| | Day1 | | | | Day 2 | | | |
|---|---|---|---|---|---|---|---|---|
| | P1 | P2 | P3 | P4 | P1 | P2 | P3 | P4 |
| P1 | 1.00 | -.633* | .122 | .792** | 1.00 | -.703* | -.184 | -.278 |
| P2 | | 1.00 | -.500 | -.730 | | 1.00 | .013 | .266 |
| P3 | | | 1.00 | .306 | | | 1.00 | .276 |
| P4 | | | | 1.00 | | | | 1.00 |

| | Day 3 | | | | Day 4 | | | |
|---|---|---|---|---|---|---|---|---|
| | P1 | P2 | P3 | P4 | P1 | P2 | P3 | P4 |
| P1 | 1.00 | -.649* | .071 | .563 | 1.00 | -.760** | -.504 | -.843** |
| P2 | | 1.00 | .437 | .489 | | 1.00 | .013 | -.511 |
| P3 | | | 1.00 | .315 | | | 1.00 | .581 |
| P4 | | | | 1.00 | | | | 1.00 |

Remarks:

* Correlation is significant at the 0.05 level (2 tailed)

** Correlation is significant at the 0.01 level (2 tailed)

On day 3, the correlation coefficient of pay point 1 and pay 2 is (0.649). The result shows a strong negative relationship and it is the only correlation coefficient that is significant at 5% level. Although, the correlation coefficient between pay point 1 and pay point 3, pay point 1 and pay point 4, are positive with values (0.071) and (0.563) respectively, the two values are neither significant at 1% nor at 5% level but the former has positively weak correlation and the latter has a positively moderate correlation. The correlation coefficient between pay point 2 and pay point 3 is (0.437), pay point 2 and pay point 4 is (0.489), and pay point 3 and pay point 4 (0.315) are weak and they are neither significant at 1% level nor 5% level.

Correlation coefficient between pay point 1 and pay point 2, and pay point 1 and pay point 4 are the most significant in the correlation matrix for day 4. There is a negatively strong correlation coefficient between pay point 1 and pay point 2 with a value (-0.706) and pay point 1 and pay point 4 (-0.843) which are significant at 1 % and 5% levels. Pay point 1 and pay point 3 have correlation coefficient of (-0.504), which shows a moderately negative relationship between the pay points. Correlation coefficients between pay point 2 and pay point 3; pay point 2 and pay point 4; and pay point 3 and pay point 4 are (-0.457), (-0.511) and (0.581) respectively, all of which are not statistically significant at 1% and 5% levels. However, the first having negatively weak, the second having moderately negative and the third having a moderately positive correlation coefficients.

**Tested Hypotheses**

Two hypotheses were set for this study. The first is based on hourly variations of traffic intensities and the second on daily variations of traffic intensities. Information on Table 2 and Table 3 were used to determine the first and second hypotheses, which are stated in their null and alternative form as:

I $H_0$: There is no significant variation in the means of hourly traffic intensities amongst the four pay points for cars at the toll plaza.

$H_1$: There is a significant variation in the means of hourly traffic intensities amongst the four pay points for cars at the toll plaza.

II $H_0$: There is no significant variation in the means of daily traffic intensities amongst the four pay points for cars at the toll plaza.

$H_1$: There is a significant variation in the means of daily traffic intensities amongst the four pay points for cars at the toll plaza.

Results of ANOVA Tables generated from Statistical Products for Social Services for hourly and daily traffic intensities are shown on Table 5 and Table 6 respectively. Results on Table 5 however, shows that calculated F - ratio for hourly traffic intensities for day 1, day 2, day 3, and day 4 are 18.589, 10.767, 25.454 and 10.116 respectively which are significant at 5% level of significance with value of 2.84. It therefore implies that there is a significant variation in the degree of hourly daily traffic intensities amongst the four pay points for cars.

Table 5. ANOVA Results of Hourly Traffic Intensities

| Traffic intensities | Sum of squares | Degree of freedom | Mean squares | F-ratio | F at 5% level of significance |
|---|---|---|---|---|---|
| Day1 | | | | | |
| Between group | 5.383E-02 | 3 | 1.794E-02 | | |
| Within group | 3.861E-02 | 40 | 9.653E-03 | 18.589 | 2.84 |
| Day2 | | | | | |
| Between group | 5.331E-02 | 3 | 1.777E-02 | | |
| Within group | 6.601E-02 | 40 | 1.650E-03 | 10.767 | 2.84 |
| Day3 | | | | | |
| Between group | 0.181 | 3 | 6.033E-02 | | |
| Within group | 9.481E-02 | 40 | 2.370E-03 | 25.454 | 2.84 |
| Day4 | | | | | |
| Between group | 9.250E-02 | 3 | 3.083E-02 | | |
| Within group | 0.122 | 40 | 3.048E-03 | 10.116 | 2.84 |

Source:Generated using SPSS Package, 2003.

As shown on Table 6, calculated $F = 22.690$ and F- ratio at 5% significant level is $F_{20}^{15}=1.67$ and this means that there is a significant variations in the degree of hourly traffic intensities amongst the four pay points for cars for the four days. Hence, the hypothesis is statistically significant. It therefore means that the queue formed as a result of delay at the toll plaza varies hourly from pay point 1 to pay point 4 for the four days.

Table 6: ANOVA Results of Hourly Traffic Intensities from day 1 to day 4

| Traffic intensities | Sum of squares | Degree of freedom | Mean squares | F-ratio | F at 5% level of significance |
|---|---|---|---|---|---|
| Between group | 0.684 | 15 | 4.557E-02 | | |
| Within group | 0.321 | 60 | 2.008E-03 | 22.690 | 1.67 |

Source: Generated using SPSS Package, 2003.

However, the ANOVA result of daily traffic intensities at the four pay points for cars (see Table 7) show that calculated F- ratio (2.515) is less than tabulated F – ratio (3.49). It therefore means that, at 5% level of significance, there is no significant variation in the daily traffic intensities at the four pay points for cars at the toll plaza. Hence the hypothesis is statistically insignificant.

Table 7: ANOVA Result of Daily Traffic Intensities from day 1 to day 4

| Traffic intensities | Sum of squares | Degree of freedom | Mean squares | F-ratio | F at 5% level of significance |
|---|---|---|---|---|---|
| Between group | 2.067E-02 | 3 | 6.890E-02 | | |
| Within group | 3.287E-02 | 12 | 2.740E-02 | 2.515 | 3.490 |

Source: Generated using SPSS Package, 2003

**Pattern Of Vehicular Traffic Flow At The Toll Plaza**

The pattern of vehicle flow, particularly cars at the toll plaza can be expressed in three ways. These include (i) Morning Rush Hours, (ii) Afternoon Rush Hours, and (iii) Evening Rush Hours.

**Morning Rush Hours**

At the toll plaza, there is a morning rush hour for vehicles particularly at the pay points for cars. The morning rush hour is between (8am to 11am). In between these hours, cars arrival is spontaneous, and it is the period hawkers try to contribute to the delay at the toll plaza. Observation on the field showed that morning rush hour is characterized by vehicles trying to leave their places of origin early so as to reach their destinations at specified transit time. Most people work in Ibadan, Lagos and Abeokuta but live in Sagamu, Ijebu - Ode and other neighbouring towns. In order to make their trip early to work, they had to leave early. It is quite interesting to note that this pattern of traffic flow determines the kind of food items hawkers' display. During this period, food like Rice, Cake, Bread, Banana chips, Egg roll to mention but a few are sold by the hawkers. Most of these hawkers however, are elderly people that have taken hawking as their business at the toll plaza.

**Afternoon Rush Hours**

The afternoon rush hours occur between (12 pm - 2pm) and most times (2pm- 4pm). Traffic congestion at these periods occurs interchangeably. If there is little traffic from (12pm-2pm), by (2pm- 4pm), heavy traffic would come to the scene. Trading activities at these periods by hawkers involve movement from one end of the highway to the other particularly where the traffic is heavy and there is no aggressive display of food items at car windows. However, foods like rice, beans are no more visible. Bread, Egg roll, Plantain chips, apple, Bottled and cellophane packed water popularly called 'pure water' and soft drinks are the products sold. It is equally good to note that around (2pm - 4pm), the number of young hawkers increases because they have returned from their various schools and are mostly found selling cellophane packed water.

**Evening Rush Hours**

The evening rush hour is between (4pm - 6pm). At this period, there is spontaneous arrival of vehicles from both directions of the highway. The rush at this time of the day can be attributed to many factors. These factors include (i) most drivers find it difficult to drive at night, (ii) the fear of being attacked by armed robbery which is rampant along the highway, (iii) avoidance of accidents and (iv)the bad condition in some parts of the highway.

After 6pm, cars arrival decreases considerably to one or two cars in every five minutes. When it is 7pm, one can hardly see vehicle arriving at the rate at which they have been at other rush hours. At this period, there is a reduction in the number of hawkers, most notably young hawkers selling cellophane packed water.

**Factors Affecting Traffic Flow At The Toll Plaza**

During rush hours, long queues are formed and the issue of arrival rate or inter arrival rate versus service rate or average service rate bringing about traffic intensity at the toll plaza factor in. However, we observed that there were factors affecting traffic flow at the toll plaza other than arrival and service patterns. These factors include the followings: (i) Erection of Mild Bumps at the pay points, (ii) Break down of vehicle at the pay points, (iii) Indiscriminate Parking at the toll plaza, (iv) Hawkers selling their products at the pay points, (v) Presentation of Higher Denominations at the pay points, (vi) Uniformed Men stationed at the toll points, and (vii) Indiscriminate use of toll points by motorists.

**Erection of Mild Bumps**

At the pay points for cars, the management of the toll plaza erected mild bumps at each pay point so as to reduce the speed of cars and to prevent cars from evading tickets as well. These bumps reduce the speed of vehicles during coming and going.

**Break Down of Vehicle**

Most vehicles, particularly trucks and other articulated vehicles do develop mechanical fault at the pay points or some meters away from the pay point. For example, during the days of data collection, there was hardly a day without one or two vehicle(s) especially articulated vehicle that broke down in the middle of highways around the pay points. When such incident happened, long queues were formed and prevented the free flow of all vehicles..

**Indiscriminate Parking**

Indiscriminate parking at the toll points also hindered the flow of traffic and adds tothe queue of vehicles as well. Most articulated vehicle drivers found the toll plaza as convenient places to park or as garage, and thus reduce available space on the highway. The attitude of these drivers at the toll plaza did contribute to accidents particularly by drivers plying the route for the first time.

**Hawkers Activities**

Hawkers carrying out their daily trading activities also hindered free flow of traffic at the toll plaza. At rush hours, these hawkers are found at the middle of the road before the toll point, at the toll points and after the toll points selling food items to passengers. While bargaining, drivers are forced to slow down or stop at the pay points. Apart from being a dangerous venture, they constitute terrible obstruction to free flow of cars.

**Presentation of Higher Denominations**

Presentation of higher denomination bills at the pay points also constitutes hindrance to free flow of cars at the toll plaza. Most car drivers do present higher denomination of naira to the toll attendants and the duration they had to wait for their change, which most of the time took up to five minutes, did nothing but extend the queue.

**Law Enforcement Officers**

Police, Custom and Federal Road Safety Officers stationed at the toll plaza do constitute hindrance to free flow of traffic at the toll plaza. These custom officers' attempt to arrest second hand cars popularly call 'tokunbo', usually forced other road user at the toll plaza to a standstill. Police officers on the other hand, turned the pay points to check points where particulars of vehicles are checked.

Interestingly, these officers were happy whenever there was a long queue. This was because the queue will give them the opportunity to scan for defaulting cars.

**Indiscriminate use of Toll Points**

Indiscriminate use of these pay points by commercial bus drivers who try to evade their toll price also constitute hindrance to the flow of traffic at these pay points. Most of the time, their actions often resulted in fatal accidents.

## CONCLUSION

Predicting the behaviour of queue forming at given facilities would help in better understanding and the utilization of such facilities to reduce waiting time. It is therefore recommended that:

1) There is the need for bold inscription that says 'CARS' at the pay points in order to prevent indiscriminate use of the pay points meant for cars by trucks.
2) Hawkers should be restrained from using the pay points to show case their products.
3) Policemen, Custom officers, Federal Road Safety Corps and other government officials should be discouraged from using the pay points as check points.
4) The toll plaza must have facilities such as towing vehicles to move aside stalling vehicles at the toll points.
5) Erection of mild bumps before and after the toll points increases traffic congestion and queue particularly during rush hours. It is advisable to erect sign post 100 meters and 50 away before the approaching point of the toll plaza. This will caution motorists to reduce their speeds.
6) Erection of electronic signs at the toll plaza would also be of importance rather using bumps.
7) The authority of the toll plaza should discourage the use of the toll plaza as terminal where different vehicles can pack.
8) Government can create packing facilities some kilometers away from the toll plaza. This would not only be a terminal that would enhance the socio-economic activities of the people but also serves as source of revenue generation for the government.

Queuing has been a common phenomenon that occurs in every area of our life. From the fetus to birth (waiting approximately nine months), until death (an entire life) there are many moments where human beings find themselves waiting for things, events, conditions and so on. Queuing model therefore aims at enhancing numerical measure of our uncertain understanding on the nature of traffic flow, appreciating the randomness of car arrivals at the toll plaza which could either be based on assumptions which at times evolve in natural processes, not concluding that a natural process follows a particular probability model unless so proven, and shaping our understanding or approach to deal with the limitations of our knowledge on natural processes, which can enhance traffic count at the toll plaza.

## ACKNOWLEDGEMENT

The authors would like to thank to an anonymous reviewer for improving the manuscript.

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