ANALYSIS OF LANE CHANGING AND OTHER TRAFFIC CHARACTERISTICS IN THE VICINITY OF JEEPNEY STOPS*

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1. Introduction

Paratransit vehicles are often maligned for their behavior along urban thoroughfares. The basis for this is the perceived influence of paratransit operation on the traffic flow characteristics along urban roadways, particularly on the aspects of traffic congestion and safety. Jeepneys in Metro Manila have been observed to employ various maneuvers as they move toward the curbside to make a stop[1]. A similar situation applies when they move out from the stop. This merging and diverging behavior is characterized by frequent lane changing. However, lane changes are not exclusive to jeepneys (or other paratransit) but are common even to private vehicles, which may change lanes, for example, to avoid stopping jeepneys. As such, lane change behavior represents the dynamic interaction among vehicles in the traffic stream and occurs under varying conditions or situations. This paper examines lane changing together with other traffic characteristics in the vicinity of jeepney stops.

2. Objectives

This study has three main objectives. The first is to present the various aspects of lane-changing behavior. This will include pointing out the similarities and differences between highway and arterial lane changes. The second objective is to investigate the relationship between lane changing and other traffic characteristics in the jeepney stop environment. To accomplish this, it is necessary to undertake quantitative analysis of factors affecting lane changing which are found in the vicinity of jeepney stops. The last objective is to explain the importance of studying lane changing. Particularly, the paper will discuss applications of analytical results and propose directions for future research.

3. Lane Changing Along Highways

There have been a number of studies pertaining to lane changes. Among these are findings made by Leutzbach[2] regarding the relationship between the total traffic volume and the frequency of lane changes along German autobahns. The general observation was that the frequency of lane changing increases as the total traffic volume increases. However, this increase in the volume is accompanied by an increase in vehicle concentration, which in turn limits the opportunities for changing lanes. Thus, a certain threshold value is reached, from where the frequency of lane changes decline with increasing total traffic volume. Such a relationship is illustrated in the following Fig. 1.

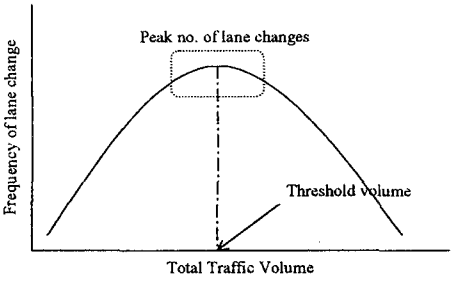

Fig. 1. Relation between total traffic volume and lane changing frequency.

The results from studies made by Heidemann[3] and Yousif[4] validated Leutzbach's observation. The first modeled lane utilization and lane changing relationship along 2-lane and 3-lane unidirectional sections along German autobahns while the second modeled similar sections along British motorways. It was found that the frequency of lane changes declines beyond flows of 2000 veh/h for 2-lane sections and 3000 veh/h for 3-lane sections.

It should be realized that while there are similarities between lane change behavior along expressways (or motorways/autobahns) and urban arterials, their differences should no be disregarded. The similarities lie mainly on the decision-making process (i.e., Why change lanes?), which is discussed in a succeeding section. Meanwhile, the distinguishing element for lane changing along arterials is the presence of public transit as well as signalized intersections (i.e., traffic flow along expressways is classified as uninterrupted while arterial flow is under interrupted conditions). In this paper, we focus on the influence of the operational characteristics of jeepneys on traffic flow along arterials, especially lane changing.

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4. Data

(1) Selected Variables

In the conduct of the study, several quantitative and qualitative variables were considered. These variables comprised mainly of traffic characteristics which have been found[2)-4)] to influence lane changing. The quantitative variables included the fundamental parameters: volume (q), speed (u) and concentration (k). From these variables, we are able to derive other parameters such as lane utilization and the traffic mix. The qualitative variables included knowledge about vehicle occupancy, jeepney routes and driver attitudes. These were used to reinforce the interpretation of results.

(2) Data Collection Process

Data collection was facilitated by conducting video surveys at two different sites along an arterial in Metro Manila. The footage allowed for encoded data to be counterchecked to minimize errors that may be incurred in the field. Both segments chosen were 4-lane, straight, level midblock sections. Pavement condition was satisfactory and lane markings were existent. Segment lengths were 40m and both were located approximately 200m from a signalized intersection upstream. Note that despite the existence of designated stops and regulations for such, jeepneys are able to stop almost anywhere along the roadway to load and unload passengers.

5. Analysis Of Lane Changing

(1) Factors affecting lane changing

The study of lane changing is made complex by the many factors affecting this behavior. It has been mentioned in the previous section that tendencies in lane changing are affected by several variables. However, to go into more detail about its mechanism, it is necessary to answer the fundamental question: Why change lanes? Yousif[3)] listed several reasons for changing lanes. Among these are: (a) individual lane preference, (b) surrounding traffic concentration on adjacent lanes, (c) surrounding average speed on adjacent lanes; and (d) general traffic regulations. From such reasons, it is easy to identify the main factors influencing lane change. These factors are common to both expressways and urban arterials and may not be considered as mutually exclusive of each other. The decision to change lanes is obviously the result of the combination of various factors that make conditions for switching lanes possible. Individual lane preference refers to factors involving the driver and the type of vehicle he is handling. Consequently, driver behavior or motivation influences lane choices. Drivers of private cars may tend to choose lanes where they can maintain a certain average speed. Meanwhile, jeepney drivers (or public transport drivers, in general) will choose to move towards the curbside lane to load and unload passengers.

The perception of lower densities along adjacent lanes will influence drivers to switch to those lanes. It is a natural tendency to transfer to a lane where one will be able to drive more comfortably (larger spacing between vehicles), if not necessarily faster. Note also that at higher densities, lane change will be restricted due to the lesser number of acceptable gaps available to change lanes. Switching towards a lane of higher average speed reflects the desire to move in a faster stream. Unless preferring to drive slowly themselves, most drivers would want to avoid slow moving vehicles. Moreover, in the case of arterials where public transport vehicles operate, drivers tend to avoid stopping vehicles. Here, it is easy to see the relation between lane speed and lane density. Higher vehicle concentrations along a lane lead to a perception of slower average lane speeds and vice versa.

At this point, it is necessary to refer to a previous section where the relationship between lane change frequency and the total traffic volume was described. Similarly, the frequency of lane changes was plotted against increasing total traffic volume and is shown in Fig. 2. The significance of this figure lies in the realization of similar tendencies of lane change frequency along an arterial segment with that of expressways. That is, the frequency of lane changes increases with increasing traffic flow until such a time when the concentration of traffic restricts the probability of changing lanes and the frequency declines as flow further increases. This can be seen from Fig. 2 for the case of all vehicles and jeepneys in particular for both Segments I and II. Finally, general traffic regulations refer to various policies that may affect lane change behavior. Metro Manila experimented with what was termed as "yellow lanes" which attempted to separate private and public transport vehicles. Under such a rule, jeepneys and buses were encouraged to stay along the curbside lanes while private vehicles were not allowed to use these lanes unless in the act of turning right at an intersection. Such rules may have a direct influence on lane changing behavior and may help explain certain patterns in lane changing.

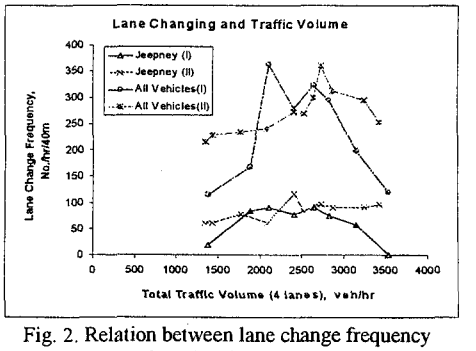

Fig. 2. Relation between lane change frequency and total traffic volume.

(2) Lane changing behavior and lane utilization

From the perspective of congestion, it is easy to see that lane changing may have a direct influence on lane utilization. It was mentioned earlier that previous studies have linked lane change behavior with lane utilization. The following figures show

plots of lane utilization against the total traffic volume for the two segments considered in this study. Note that lane changes are not explicitly included in the plots.

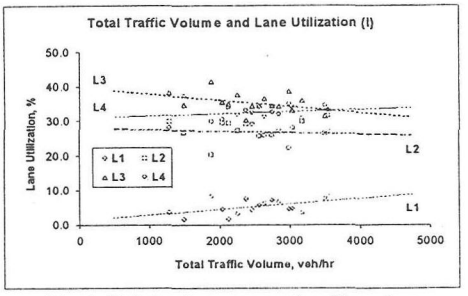

Fig. 3. Relation between total traffic volume and lane utilization for Segment (I).

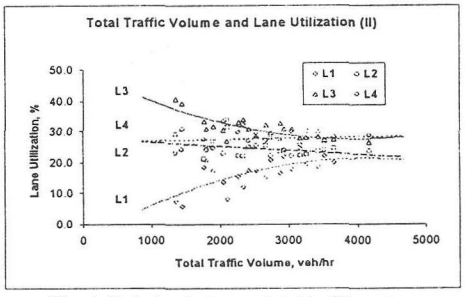

Fig. 4. Relation between total traffic volume and lane utilization for Segment (II).

The two figures show different conditions along each segment. On the same vertical and horizontal scales, it can be seen that the value for lane utilization along Segment (II) converged at higher volumes. Meanwhile, there is no clear pattern along Segment (I) aside from the apparent underutilization of the curbside lane. These differences may be explained by the prevailing conditions at the time the data was taken. It must be realized that lane changes and lane utilization have a dynamic relationship. Lane utilization is a product of the number of vehicles switching lanes while lane changes are influenced by the perceived concentration of vehicles along a particular lane (hence its utilization). Such a relationship will be clarified in the succeeding section.

(3) Distribution of Lane Change Activity

Lane changing activity was classified into 6 movements. Such classification was made to adapt to the segment length as well as to simplify the lane change process to be analyzed. Note that unlike previous studies[3)-5)] in lane changing, the segments considered here is relatively short. In multilane sections, longer segments permit the shift from the median lane, for example, to the curbside lane. This will only complicate analysis since the number of movements to be considered is increased. With shorter segments, lane changing is constrained to adjacent lanes. These lane change movements are shown in Fig. 5.

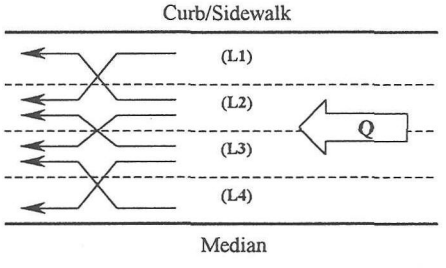

Fig. 5. Lane change movements.

It can be stated from Fig. 5 that 2 adjacent lanes (e.g., 2-lane unidirectional section) will have 2 movements and that each additional lane will result in 2 more movements. Thus, a 3-lane unidirectional segment will have 4 lane change movements. The tendencies of lane changes for jeepneys and other vehicles along Segments (I) and (II) are shown in Figs. 6 and 7. The tendencies shown in the figures above are affected by factors/sub-factors such as location, time of day, passenger demand and transit routes. As such, variations from the figures shown are expected and dependent on the circumstances by which the data was collected. From Fig. 6, it can be seen that jeepney lane changing is concentrated along lanes 1 to 3 while other vehicles tend to switch over lanes 2 to 4. This is easy to understand since jeepneys were observed to stop frequently (34 stops per hour) along Segment (I). Thus, most jeepney lane changing occurs toward the curbside. In the case of other vehicles, it is noted that a significant number of those changing lanes do so from L3 to L2. This activity is rationalized by the underutilization of L1 as shown in the previous Fig. 3. A lower concentration of vehicles is perceived along L1 and L2, which then induces vehicles to transfer towards it.

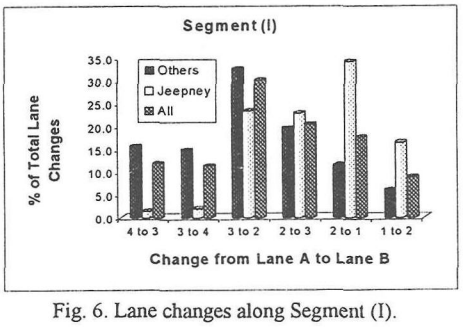

Fig. 6. Lane changes along Segment (I).

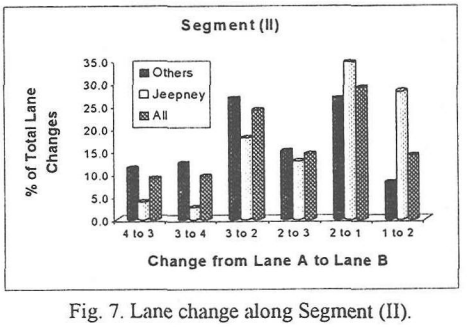

Fig. 7. Lane change along Segment (II).

Along Segment (II), a similar trend for jeepneys is again realized. Moreover, it can be seen from Fig. 7 that most lane changing activity occurs between adjacent lanes 1 and 2. This behavior highlights the operation and concentration of jeepneys along the two outermost lanes (i.e., L1 and L2). However, it was also observed that other vehicles are switching towards these lanes. This can be explained by the fact that jeepneys seldom stop along L1 and L2 of Segment (II). As such, other vehicles are encouraged to use these lanes. To verify the results presented, we look back to a previous study on Metro Manila arterials. Sigua[5] observed that most private cars and jeepneys actually maintain their lanes with jeepneys concentrating along L1 and L2 of a similar arterial segment (i.e., 4-lane unidirectional). However, majority of lane changes made by jeepneys occurs between these two lanes. The study noted that private cars stayed away from L1 but usually switched to L2. The results for Segment (II) are consistent with these findings.

6. The Study of Lane Changing

(1) Why Study Lane Changing?

Until now, most of the discussions in this paper have focused on lane changing and traffic characteristics along segments where jeepneys stop. A major question that needs to be answered at this point is "why study lane changing at all?" Indeed, the answer to this question is not so easy. However, one needs not look further for proof on the significance of studies on lane change behavior. The previous sections have pointed out in certain detail the relationship between lane changing and various fundamental traffic characteristics including the total traffic volume, lane density and lane utilization. While more evidence is needed to firmly establish the lane change mechanism over a range of traffic conditions, the influence of lane changing on road traffic flow is strongly suggested by the results presented in this paper. Therefore, knowledge and comprehension of the fundamental lane changing characteristics are essential to better understand the nature of traffic as this behavior becomes an important factor in the evaluation of LOS.

(2) Research Directions

In this study, the jeepney stop served as a focal point of activity along two segments in a Metro Manila arterial. The results presented in the previous sections concentrated on that aspect of lane changing which is concerned with traffic flow. Again caution must be taken against generalizing the findings in this study. It should always be remembered that various other scenarios or situations are in existence, most of which may not even involve the jeepney. In the analysis of lane changing, it is also important to take note of the effects of upstream and downstream sections as well as factors like the influence of intersections and side streets. Such analysis may be accomplished using various techniques. Modelling and simulation may be employed to facilitate such a study provided that sufficient assumptions are established and proper model calibration is achieved. The study of the traffic flow aspect of lane changing is just one (if not the most important) component of it fundamental characteristic. Research must also focus attention on the behavioral aspect of lane changing. In particular, the decision-making process should be clarified in order to determine if there is a distinction between private and public transport drivers, knowing that each are influenced by different motivations. The results of such studies must then be interpreted together with the analytical results of traffic flow related studies. Therefore, it would be possible to establish a concrete understanding of the lane change mechanism.

7. Conclusion

Various aspects of lane changing were discussed in this paper. First, the similarities and differences in lane changing behavior along highways and arterials were clarified. The similarities are found mainly among the reasons for changing lanes and the tendency of lane change frequency as flow increases. The differences are found in the flow characteristics (i.e., presence of public transit activities). Second, the relationships between lane changing and other traffic characteristics were analyzed. The interrelationship between lane change, lane utilization, lane density and the total traffic volume was discussed. It was found that these variables tend to influence each other in a dynamic manner (i.e., lane change changes occur toward underutilized lanes and lane utilization itself is a product of the number of vehicles switching lanes). Finally, research directions were proposed in order to further the understanding of the mechanism for lane changing. In conclusion, it is emphasized that a comprehensive and more detailed examination of lane changing and the related traffic characteristics is necessary to firmly establish the fundamental characteristics of lane changing under general conditions.

8. References

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