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Analysis of Traffic Generation in an Urban Area: A Case Study of Savar Pourashava

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Abstract

Study on trip generation is one of the four steps of conventional transportation modeling process. Trip generation of an urban area is related with its socio-economic and land use characteristics. Applying this model in the study area of Savar Pourashava, attempt has been made to find out the factors, which are related with trip generation. Based on some selected variables or factors used in the spatial regression analysis, the study tries to estimate the total number of trips generated from each ward of the Pourashava. Moreover, the impact of trip generation on road transport system is identified in the study to recommend on minimizing its negative impacts for smooth operation of traffic and as well as for proper traffic management.

Introduction

Trip generation is one of the four steps of conventional transportation modeling. These steps are trip generation, trip distribution, modal split and trip assignment (Kadiyali, 2003). Trip generation is defined as the decision to travel for a specific purpose. Trip purpose can generally be classified into two types, one is zonal trip being estimated on trip purposes (i.e. school trips, work trips, shopping trips, recreational trips etc.) and the other is travel behavior being also dependent on trip purposes, such as school and work trips identified as regular trips (time of the day), and recreational and shopping trips that are identified as highly irregular trips. The attraction rate depends on number and types of retail facilities, number of employees and land use, and the production depends on car ownership, income and population (employment characteristics) of an urban area (www.ctre.iastate.edu). The objective of the trip generation stage is to understand the reasons behind the trip making behavior and to produce mathematical relationships to synthesize the trip making pattern on the basis of observed trips, land use data and household characteristics (Kadiyali, 2003).

Trip production and attraction is usually related to the three variables which considered a number of factors that are density of land use affecting production and attraction (i.e. number of dwellings, employees etc. per unit of land and higher density), social and economic characters of users influencing production, such as average family income, education and car ownership, and location like traffic congestion and environmental conditions (www.ctre.iastate.edu). Savar Pourashava has a mixed land use. The location and intensity of land use are important variables to understand the relationship between land use and the volume of urban travel (Hurst, 1970). People who live in the study area belong to different income groups, i.e. higher, middle and lower income groups. The travel behavior of inhabitants of the study area depends on trip maker's socio-economic

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characteristics and the purposes of traveling within and outside of the study area. There are variations among the wards in terms concentration and volume of activities. The number of trips produced from each ward differs from the other. The total number of trip generation has a significant impact on the overall transport system, especially to determine the width of carriage way, modal availability, accessibility to ensure smooth operation of modes as well as to determine the overall travel demand of the study area. Such a kind of study has not been conducted in the study area before. The road network in the area is developed in an unplanned way. The carriage width is also not maintained according to road hierarchy. Such practices obstruct the smooth flow of traffic in the study area. The situation thus creates traffic congestion in some hot spots and wastes valuable time of the trip makers.

The land use development is increasingly going on at Savar Pourashava. Land use development affects trip generation and as well as creates a pressure on transport network. Savar has an area of 16.67 sq. km. with 9 wards and a population size of 1, 61,600 (Field survey, 2006). In an urban area, a zone with a larger number of households or employees will generate more trips than a zone with smaller number of those. The rate of trip generation is also influenced by population, labor force participation rate, work at home (change in proportion of labor force that works outside the home), daily first work trips per person employed outside the home, morning work trip, peak-period factor (fraction of daily work trips occurring during the morning peak period), non work trip adjustment factor applied to work trips, total morning peak period trip origins and morning peak period work trip destinations i.e. at the place of work (Miller and Briggs, 1998). The land use development intensity is not the same in all the zones, and there is also a variation in trip generation between different wards of the Pourashava. Based on the trip generation analysis, it is easy to adopt measures for improving transportation facilities for the people of the study area for their convenience and comfort.

The population of the study area is increasing day by day, because of its close proximity to Dhaka City. Savar is declared as new urban development area in Dhaka Metropolitan Development Plan (DMDP, 1995). Because of its better communication system with Dhaka City and its surrounding areas, there is potential for faster population growth at Savar in the future. It is also a suitable place for growing industry, trade and commerce. For accommodating increasing population and to facilitate the commercial activities in the study area, the land use is being rapidly changed. It is necessary to emphasize on the overall development so as to control the hazardous or unplanned growth. Since, Savar has a mixed land use pattern and various income groups of people (i.e. higher, middle and lower income groups) live in different wards, the trip generation from different wards varies, because the volume of trip generation depends on various factors, like population density, number of households, commercial activities etc.

Objectives and Methodology of the Study

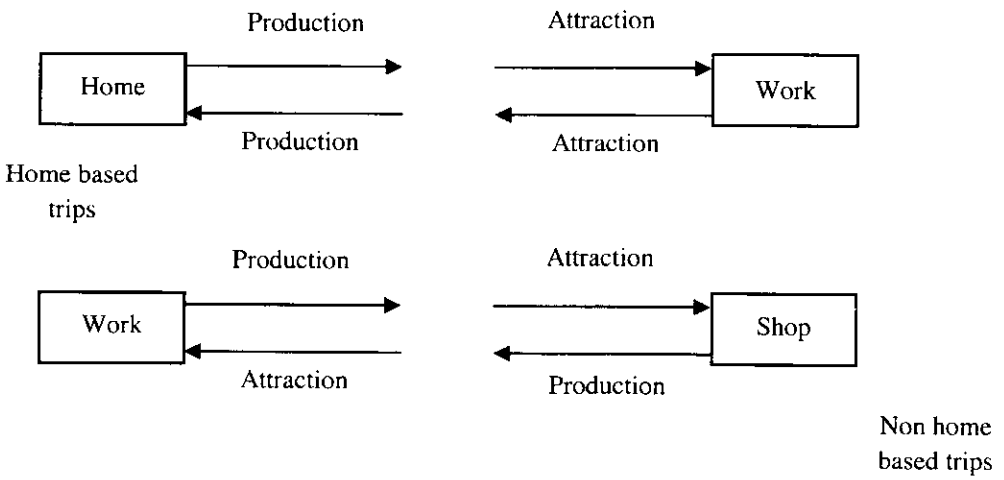
The objectives of the study is to find out the factors responsible for trip generation, to estimate the total number of trips generation from the study area by using spatial regression analysis and to analyze the impact of trip generation on transport network. Both primary and secondary data were used to create shape file and determine Moran's I

by using ArcGIS 9.2 and Geoda095i software. Partial co-efficient (r^2) of the variables used in the study and the value for constant 'c' were determined by using Geoda095i software for selection of the best regression models from Classic Model, Spatial Error Model and Spatial Leg Model and to estimate the total number of trip generation in the study area.

Classification of Trips

A trip is a one way person movement by a mechanized mode of transport, having two trip ends, an origin (the start of the trip) and a destination (the end of the trip). A generation is the home end of any trip that has one end at the home and is the origin of a trip neither end home based (i.e. of a non home based trip). An attraction is the non home end of a home based trip and is the destination of a trip with neither end home based i.e. of a non home based trip (Kadiyali, 2003).

Trips are classified based on trip purpose and person type. Trip purpose includes home based trip such as work, school, shopping, social, recreation and others, whereas non home based trip is not classified into categories (Figure 1). Person type trips depends on income level, car ownership, household size and household structure i.e. group housing, single, family head, family worker (Dixon, 2011).



Source: Rao, K. K. V. and Mathew.V. T. 2007.
Fig. 1: Trip types

Factors Affecting Trip Generation

Trip generation depends on various factors and it is very important in transportation planning process. To identify the travel demand of an urban area and for improvement of the existing facilities as well as establishment of new facilities, trip generation analysis plays a vital role. The main factors affecting personal trip production include income, vehicle ownership, house hold structure, family size, residential density and accessibility (Rao and Mathew, 2007). Studies on trip generation analysis denote that trip generation analysis usually is stratified into two components i.e. trip generation at the household level and trip generation at the non-residential level. At the household level,

characteristics that are usually considered for trip generation include car ownership, income, density of development and household size. The household generation results generally are used as a "control" on the total non-residential generation, which usually considers characteristics, such as employment, type of land use (retail, office, etc.), and type of area (CBD, suburban, shopping center, etc.). "Special generators" such as the airports and stadiums are usually separately handled from the rest of-the analysis, because of their unique travel generating characteristics. This study emphasized that trip generation is important to the traffic engineer in considering the impact of a new office complex, shopping center or residential development. The amount of traffic a new development generates, the necessary upgrading or improvement to existing facilities, traffic control requirements and new connecting facilities are important in this consideration. For the purpose, trip generation is obviously most pertinent relative to traffic at a specific land use activity (U.S. Department of Transportation, 1975). In the study, the factors which are taken to determine the number of total trips from each ward of Savar Pourashava and as well as from the study area are population density, number of household by main source of income, number of industry, commercial activities, retail shops, institutions and also number of employees (Table 1).

Analysis of Trip Generation

In the study, ArcGIS 9.2 and Geoda095i software are used for analysis of total trip generation from Savar Pourashava. ArcGIS 9.2 is used for creating shape file of the data base and Geoda095i is used for determining Moran's I and analysis of three regression models from which the best model is selected based on the value of partial co-efficient (r^2).

Creation of Shape File

The GIS data base prepared under UGIIP project of the study area is collected from respective Pourashava office. With the help of GIS data base, the shape files for different variables, like number of household, population density and number of industry are calculated by using ArcGIS 9.2 software.

Creation of Weight File

After creating shape file, it is opened by Geoda095i software for making weight file and is opened as an input file in Geoda095i software. In this stage, ward is selected as an ID variable for weight file. Then it is saved at a location from which it is used for the determination of Moran's I. Contiguity weight is also selected for making weight file. In this study, rook contiguity is selected for the study purpose. The weight file is saved as GAL format.

Determination of Moran's I

The Moran's I is determined to follow two steps by using the software. The first step is rate smoothing and the next step is selection of weight file. In the rate smoothing, base variable and event variable are selected. In the analysis, ward is selected as base variable and population density is selected as event variable. After determining the rate smoothing, the weight file is selected from the file, where it is saved in gal.gwt format. To complete these procedures, Moran's I is determined and the value of Moran's I is 0.0536.

Table 1: Data Base for determination of trip generation.

Name of Ward Data base	Ward 1	Ward 2	Ward 3	Ward 4	Ward 5	Ward 6	Ward 7	Ward 8	Ward 9
Population density/sq.km	7349	21710	12643	32758	23877	10133	8970	6254	5935
No. of respondents	550	550	550	550	550	550	550	550	550
No. of households	3376	3298	2956	2668	3262	5174	4337	6570	2574
No. of household by main source of income	3333	3267	2897	2134	3146	4582	4262	2660	2456
No. of employees	348	260	322	319	249	228	411	435	166
No. of industries	02	04	00	02	08	29	10	07	17
No. of commercial center	17	25	7	02	04	3	10	03	02
No. of retail shops	206	112	30	120	400	100	350	125	400
No. of institutions	09	06	08	13	16	06	09	09	07
No. of trips	8332	8167	7242	5335	7865	11455	10655	6650	6140

Source: GIS data base of Savar Pourashava, 2006; Population Census, 2007 and Field survey, 2010.

Determination of Co-efficient

Finally, the co-efficient for using variables in the study like household, population density etc. and the partial co-efficient for different regression models are determined. Based on the value of partial co-efficient, the best model is selected for this analysis to get good result. At this stage, Moran's I is selected.

Two variables are used in this analysis i.e. dependent variable and independent variable. Trip generation is selected as dependent variable and other variables are selected as independent variables. In the same way, the co-efficient of using variable in the study for the three regression models are determined. The constant value, standard deviation and the value of co-efficient are used in multiple regression analysis for determining the total number of trips from each ward of the study area.

Regression Models Used for Trip Generation Analysis

Three regression models are used to select the best model for trip generation analysis for the study purpose. The models are given below:

- Classic Model,
- Spatial Error Model, and
- Spatial Leg Model.

Based on the value of "r^2" (partial co-efficient), which is determined by using Geoda095i software, the best model is selected. The model, which has the highest value of "r^2", is selected as the best model to determine the total trip generation from the study area. From Table 2, it is found that Spatial Leg Model is the best for analysis of trip generation.

Table 2: Estimated Value of partial co-efficient.

Regression Models	Partial Co-efficient	Estimated Value
Classic Model	"r^2"	0.974
Spatial Error Model		0.999
Spatial Leg Model		1.0

Source: Value estimated by using Geoda095i software.

Co-efficient of Different Variables

The variables, which are used for determining the total trip generation from the study area, are household, population density, number of industry, number of commercial (small trade and commercial center) activities, number of retail shops, number of institutions and number of employment. The co-efficient of these variables are determined by using Goeda095i software. The values co-efficient determined are given in Table 3according to regression models.

Table 3: Co-efficient of different variables according to regression models.

Regression Model	Variables	Co-efficient
Classic Model	Household	-1.628
	Population density	1.145
	No. of industry	-3.374
	No. of commercial activities	74.974
	No. of retail shops	0.112
	No. of institutions	125.125
	No. of employment	6.385
Spatial Error Model	Household	-1.517
	Population density	0.982
	No. of industry	-6.986
	No. of commercial activities	66.180
	No. of retail shops	-1.880
	No. of institutions	136.712
	No. of employment	4.401
Spatial Leg Model	Household	-1.851
	Population density	1.178
	No. of industry	-78.312
	No. of commercial activities	20.964
	No. of retail shops	0.926
	No. of institutions	69.875
	No. of employment	3.575

Source: Estimated by using Geoda095i software.

Determination of Constant Value

The constant value of "c" is also found from estimation by using Geoda095i software is given in Table 4 for classic, spatial error and spatial leg model.

Table 4: Constant value "c" for different models.

Regression models	Determinant	Value
Classic Model	Constant "c"	598.629
Spatial Error Model		2321.144
Spatial Leg Model		7853.380

Source: Estimated by using Geoda095i software.

Multiple Regression Equation

In the study, multiple regression is used for determining the total number of trips from each ward of Savar Pourashava. The regression equation (Can and Megbolugbe, 1997), which is used for this purpose is given below:

$$y_i = c + \sum_{j=1}^{n} B_j x_{ij} + \varepsilon$$

or

$$y_i = c + \sum_{j=1}^{n} B_j x_{ij} + \sigma^2 I$$

Where,

y_i is the amount of traffic generation in i^{th} wards

x_{ij} is the j^{th} attribute for the i^{th} wards

B_j is the parameter to be estimated for the j^{th} attribute

ε is the random error

σ^2 is the standard deviation and I is the Moran's I

By using the regression equation, total number of trips generated from each ward is determined. The total number of trips generated from ward 1 is calculated by using the following formula.

$$\begin{aligned} y_{\text{ward}1} &= 7853.38 + (-1.851 \times 3333) + (1.178 \times 7349) + (-78.312 \times 2) + (20.964 \times 17) + \\ &\quad (0.926 \times 206) + (69.875 \times 9) + (3.575 \times 348) + (1888.52 \times 0.0536) \\ &= 12{,}706 \end{aligned}$$

In the same way, total trips generated from each ward are determined. Ward wise number of generated trips are shown in Table 5.

Table 5: Ward-wise number of generated trips.

Ward No.	No. of generated trips	Rank
01	12,706	5
02	29,145	3
03	19,370	4
04	44,639	1
05	32,094	2
06	10,529	9
07	12,481	6
08	12,213	7
09	10,563	8

Source: Estimates used by regression equation.

From the analysis, it is found that the total number of trips generated from the study area is 1, 83,740 and the highest number of trips is about 44,639 are generated from the ward 4. Ward 5 and 2 are in the second and third positions respectively according to generation of trips.

Impact of Trip Generation on the Road Network System

The amount of trip generation from an urban area creates a tremendous pressure on the existing transportation facilities. The travel demand analysis can be easily made by determining the total number of trips generating from each ward of the study area. Based on this calculation, the modal accessibility can also be determined, which is available to serve the inhabitants of each concerned ward or not. Roadway design is also dependent on trip generation, such as carriageway width, sidewalk or footpath for pedestrian movement. In addition, what types of modes are suitable for any particular road network, its width, volumes and intersection is designed to ensure smooth operation of traffic and to reduce traffic congestion of the study area. If the existing facilities do not support the system with the increasing trips from any ward of the study area, the system will be collapsed. As a result, mobility is hampered and also traffic congestion will be a common scenario in the study area.

Trip generation is also related with land use development. An urban area, where land use is intensive, it is predicted that more trip will be generated from that area. If existing road network, especially the local street is not designed to consider trip generation rates, the existing facilities can not serve the intensive area, where land use is changed so rapidly. Trip generation also helps identify alternative system to ensure smooth flow of traffic as well as congestion free transport system. Trip generation study is necessary to determine the impact of new development i.e. development of new office complex, commercial center as well as residential development. To meet the future demand for generating traffic, the improvement of existing facilities and traffic control requirements, which are required for better accessibility and mobility, are properly forecasted in such a study. Otherwise, the system can not be coped with the increasing demand of the transportation system and obviously the system will be collapsed.

Findings of the Study

Trip generation study is one of the four steps of conventional transportation modeling process i.e. trip generation, trip distribution, modal split and traffic assignment. In the study, it is found that trip generation depends on various socio-economic and land use characteristics. The socio-economic variables are income, car ownership, household size, number of employees etc. The trip generation rate also varies with the land use characteristics, such as land use intensity, residential, commercial, institutional as well as industrial. In the study, the factors, which are considered for regression analysis to determine the total number of trip production from each ward of Savar Pourashava, are population density, number of household by main source of income, number of industry, commercial activities, retail shops, institutions and also number of employees. The total number of trips produced from ward 4 are 44, 639, which is the highest number of trips among all wards of the study area. Ward 5 and ward 2 are in the second and third positions in respect of trip generation and the number of trips, which are produced from these wards are 32,094 and 29,145 respectively. About 12,706 trips (ward 1) and 19, 370 trips (ward 3) are produced from the concerned area. The lowest number of trips are produced from ward 6, which are 10,529 compared with other wards of the study area. The trips which are generated from ward 7, 8 and 9 are 12,481; 12,213 and 10,563 respectively. The variation found in the total number of trip generation among the wards of the study area is mainly due to population density and land use characteristics of the study area.

Trip generation from the study area is also created pressure on the existing transport system. The roadway design for an urban area is based on the determination of total number of trips produced from that particular area. Otherwise, the system will not serve the population living in that area. The decision for upgrading or improvement of existing transport facilities, such as expansion of carriage width, provision of sidewalk or footpath for the pedestrian and design of road network, especially the local street, depends on the rate of trip generation of the study area. It helps to select the best option for the study area to maintain uninterrupted traffic flow and as well as to install traffic control devices for proper traffic management. The system will otherwise be collapsed and it will create traffic congestion and hamper smooth operation of traffic.

Recommendations

The number of trips produced from an urban area affects the design of its road network, such as design of carriageway width, pedestrian facilities and traffic control system for proper traffic management and as well as accessibility and mobility to ensure the smooth operation of traffic. Therefore, study of trip generation should be conducted to find out solutions for uninterrupted traffic flow. The improvement and upgrading of the existing facilities should be done regularly based on the traffic generation study. It is necessary for the management of traffic system. The trip generation rate also affects decision making on transportation option, such as what types of vehicle will use the road and volume of traffic that will be on the road in different time periods, especially on the local street. The study should be conducted to ensure modal accessibility as well as to minimize the negative impacts on the transportation system.

Trip generation is also influenced by land use development as it helps generating traffic. As a result, before providing an approval for any kind of land use development, the matter of traffic generation has to be taken into serious consideration. The number trips should be forecasted so that the existing facilities can serve the new generated traffic. The alternative system should also be designed to ensure the smooth operation of traffic for new establishment.

Trip generation builds a linkage between land use and travel. Since land use development generates traffic, the relationships should be evaluated on a regular basis for stability and applicability. Transportation planning is a continuous process and the socio-economic and land use characteristics of the study area should be evaluated to predict the change in trip generation and as well as for making an effective transportation plan for the study area.

Conclusion

Traffic generation analysis plays an important role in transportation planning. Savar Pourashava, because of its good transport system is an attractive place to people for accommodation and employment. The population of the study area is increasing day by day and the increasing population pressure forces change in land use rapidly. In the study area, there are huge employment opportunities for people, who live there and as well as for people who come from outside of the study area. The area also attracts investment in industrial and commercial activities.

Depending on the analysis of trip generation, a smooth transport network can be designed for the study area. Since the generation of trips from any particular area has a significant impact on overall transportation planning, especially to determine travel demand and modal availability for the inhabitants of the study area. The study should be done on a regular basis for development, improvement and upgrading the transport facilities. The road way design, such as carriage width for ensuring accessibility and mobility, provision of footpath for pedestrian and traffic management are dependent on the estimation of total number of trips from each ward of the study area. The design of the local street should also be made after forecasting the total number of trips to ensure accessibility of modes operating in the study area. Proper emphasis should be given for the development of road network of the study area by determining the total number of trips generated from the study area for smooth operation of traffic and as well as for proper management of the traffic system. The efforts in this research will be useful, if it encourages local institutions adopt measures on the improvement of their transportation system and future researchers undertake further studies on the topic, .

References

Can, A. and Megbolugbe, I. F. 1997. Spatial Dependence and House Price Index Construction. *Journal of Real Estate Finance and Economics*, vol. 14, pp. 203-222.

Dixon, 2011. Transportation Planning: Trip Generation. CE 573, <webs1. uidaho. Edu /ce573 /Lecture notes /...>, retrieved on March 30, 2010.

DMDP, 1995. Urban Area Plan: 1995-2005, Volume-II. Dhaka: Ministry of Housing and Public Works, The Government of People's Republic of Bangladesh:

http:// www. ctre. iastate. edu/ educweb /.../Transportation % 20 Planning % 20 Lecture .ppt, retrieved on March 30, 2010.

Hurst, E. 1970. An Approach to the Study of Nonresidential Land Use Traffic Generation. *Annals of the Association of American Geographers*, Vol.60 (1), pp.153-173.

Kadiyali, R. L. 2003. Traffic engineering and Transport Planning, 6th Edition, Delhi: Khanna publishers.

Miller, J. E. and Briggs, R. 1998. GTA Trip Generation Rates, 1986-1996. *Joint program in transportation,* University of Toronto, Canada.

Rao, K. K. V. and Mathew,V. T. 2007. Introduction to Transportation Engineering, NPTEL, May 3, 2007.

U.S. Department of Transportation, 1975. Trip Generation Analysis. Federal Highway Administration, Urban Planning Division, Washington <http: // ntl. bts. Gov / DOCS / 368TGA. html >, retrieved on March 30, 2010.