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Multivariate School Travel Demand Regression Based on Trip Attraction

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***Abstract*—**Since primary school trips usually start from home, attention by many scholars have been focused on the home end for data gathering. Thereafter category analysis has often been relied upon when predicting school travel demands. In this paper, school end was relied on for data gathering and multivariate regression for future travel demand prediction. 9859 pupils were surveyed by way of questionnaires at 21 primary schools. The town was divided into 5 zones. The study was carried out in Skudai Town, Malaysia. Based on the hypothesis that the number of primary school trip ends are expected to be the same because school trips are fixed, the choice of trip end would have inconsequential effect on the outcome. The study compared empirical data for home and school trip end productions and attractions. Variance from both data results was insignificant, although some claims from home based family survey were found to be grossly exaggerated. Data from the school trip ends was relied on for travel demand prediction because of its completeness. Accessibility, trip attraction and trip production were then related to school trip rates under daylight and dry weather conditions. The paper concluded that, accessibility is an important parameter when predicting demand for future school trip rates.

***Keywords*—**Trip generation, regression analysis, multiple linear regressions

I. Introduction

SCHOOL travel demand trends often follow a synchronized rise and fall graphs during term and off-term times, favorable and ambient conditions. Since primary school trip start from home, many school travel studies depend of home based data supplied by parents as source for predicting school trip generation. However, parents are often intuitively skeptical about the underpinning purpose of such house surveys on private issues especially those that border on family income and movements. As a result they could hastily supply glossed private information if at all. Surely, such information as input data would have significant effect on findings and may lead erroneous conclusions. In other to avoid this pitfall, the study focused on trip end attraction rather than the start of school travel. After all, in most countries including Malaysia where the study was carried out, primary school attendance is compulsory by law. In the reliable sector, urban transportation covers the movement of both people and goods within an urban area. At the individual level, urban transportation can be characterized by a trip. However, at the metropolitan area level, millions of these individual trips define urban transportation [1]. Trip generation analysis, as Meyer [3] puts it, seeks to estimate the volume of trips that will be made by individuals to work, shopping, school, and so forth, but not the flows between points within the whole system. The functioning of metropolitan cities is highly dependent on the movement of people, goods and information [4] and trip generation studies are a vital part of transportation planning, due to the recursive nature of urban transportation modeling procedure [5]. In Malaysia, trip generation has often been treated lightly with very little research works carried out. The study is an attempt to throw light on school trip attractions given that primary school trip will be generated as long primary education is compulsory.

Trip generation is a very important part in transportation planning and traffic engineering. It used as a model analysis to forecast the population, land use, economic, travels and revenues in area wide. From the trip generation, the other analysis can be carried out which are trip distributions, modal split and trip assignment. This paper discusses the result of a study carried out to For the purpose of this study, trip is defined as a journey made by pupils from their accommodations to the primary schools in the Skudai Town area or vice versa which there are a total of 21 primary schools is listed in the Skudai Town. Primary education defined by Population and Housing Census of Malaysia: State Population Report, Department of Statistics Malaysia, 1991 refers to persons who had attained the highest level at standard 1, standard 2, standard 3, standard 4, standard 5 standard 6 or its equivalent. This paper discusses the result of a study carried out to determine the primary school trip generation in Skudai Town based on school attraction. The study is an attempt to throw light on school trip attractions given that primary school trip will be generated as long primary education is compulsory. Based on the discussion so far, the remainder of the chapter will focus on the objectives, scope and importance of the study.

The purpose of this project is to determine the trip generation of primary school in the Skudai Town Area. Through the trip generation analysis, we can determine the production of the school trip among the primary school in Skudai Town. Then, the travel demand can be estimated from the analysis. The objectives of the study are to: i) determine primary school trip production and attraction rate in Skudai

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Town, ii) investigate the trip making behaviour, iii) produce mathematical relationships that synthesis trip making pattern on the basis of observed trips.The main focus of the study is on the determination of trip generation production and attraction of primary school in Skudai Town which consists of 21 schools with 24,808 total numbers of pupils. The total area of the primary school in Skudai Town is 44.8 hectare. In the other hand, this study also concern about the parking issue and the safety condition of the school in terms of volume and speed of the vehicles.

II. Literature Review

A trip is often defined as a single journey made by an individual between two points by a specified or combined modes of travel and for a defined purpose. Thus, trip generation analysis is the key to obtaining future trip ends by zones. The basic procedure is first, to relate survey-reported trip making to household characteristics and land use types by zone through regression or factor analysis using single variable or multi-variable approaches. The equation thus derived may then be applied to forecast land use data.

Since a considerable confusion can occur in the meaning of the various terms used in trip generation, it is desirable to understand the exact meaning of the various terms. 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). Trips are usually divided into home-based and non-home-based. Home-based trips are those having one end of the trip (either origin or destination) at the home of the persons making the trip, while non-home-based trips are those having neither end at the home of the person making the trip.

Briefly, it can be summarized as follows: For a home-based trip, the zone of production is the home end of the trip; while the zone of attraction is the non home end of the trip. Thus, a trip from home to work and a trip from work to home will both have a production end which is home and an attraction end which is work. For non home-based trips, the production end is the origin and the attraction end is the destination.

Once the study area has been broken into zones, the next task involves quantifying the number of trips that each zone will produce or attract. The number of trips to and from an area or zone is related to the land use activities of the zone and the socioeconomic characteristics of the trip makers. There are at least three characteristics of land use and trip-makers that are important. The density or *intensity* of the land use is important. Many studies begin by determining the number of dwelling, employees, or tenants per acre. The intensity can be related to an average number of trips per day, based on experience with the type of land use at hand. Next, the social and economic *character* of the users can influence the number of trips that are expected. Character attributes like average family income, education, and car ownership influence the number of trips that will be produced by a zone.

Finally, *location* plays an important role in trip production and attraction. Street congestion, parking, and other environmental attributes can increase or decrease the number of trips that an area produces or attracts.

A. Review of Past Studies

The New Zealand Trips and Parking Database Bureau (NZTPDB, or "the Bureau") was conducted the study of Trip Rate and Parking Database in New Zealand and Australia in 2002. The aim is to develop a large body of data which is available to all members of bureau. It is intended to improve "good practice" in the area and through shared common knowledge, to reduce needless debate at hearings and appeals on trip and parking rates. Brigham Young University's ITE student chapter conducted a Trip Generation Study to determine the number of trips generated by an average sized elementary school on 2008. The data collected represents the average weekday trip generation for Wasatch Elementary School, an elementary school with 80 employees and 629 students. A Trip Generation Study was also conducted to determine the trips generated by the elementary school during a day with a special after school activity. The data was collected the day of a school play that involved grades 3 through 6 held during the evening.

III. Methodology

In this study, a zoning system is used to aggregate the individual premises into manageable chunks for modeling purposes. The main two dimensions of a zoning system, which are related, are the number of zones and their size. The greater the number of zones, the smaller they can cover the same study area. Prior to any setting of zones, a cordon line representing the boundary of the area must be established. First step in zoning system is distinguishing the study area itself from the other area. For the purpose of the study, the cordon line set up for this study include the land area within the boundary of Jalan Skudai, Second-Link Highway, and Pasir Gudang Highway.

The primary purpose of selecting zones is to permit summarizing, within reasonably small areas, the origins and destinations of traffic. Normally, the zones are numbered and all trips with origin or destinations within a zone are assumed to begin or end at the centroid of the zone. Care must be taken to select the zones so that there are not so many of them to render analysis cumbersome. The size of a zone will be governed by the size of the survey area, density of population, and purpose of the study (Cleveland, 1964). In this study, Skudai Town divided into five zones with different area. Figure 1.0 show zoning area and location of primary school in Skudai Town. Description for zoning area in Skudai Town as stated below:

Zone 1: Taman Teratai, Taman Sri Pulai Perdana, Taman Sri Pulai, Pulai Spring, UTM

Zone 2: Taman Berjaya, Taman Desa Skudai, Taman Pulai Bayu, Taman Pulai Flora, Taman Pulai Utama, Taman Universiti

Zone 3: Kg. Laut, Kg. Melayu Bt.10, Kg. Baru, Taman Bukit Gemilang, Taman Harmoni 1, Taman Harmoni 2, Taman Jaya, Taman Muhibbah, Taman Nesa, Taman Skudai, Taman Skudai Baru, Taman Skudai Jaya, Taman Sri Putri, Taman Sri Skudai, Taman Sutera Utama, Taman Ungku Tun Aminah, Taman Tampoi Indah, Taman Tampoi Utama

Zone 4: Kg. Baru Lima Kedai, Taman Dato Yunus Sulaiman, Taman Mutiara Rini, Taman Perumahan Rakyat Lima Kedai, Taman Skudai Indah, Taman Skudai Ria, Taman Seri Orkid

Zone 5: Bandar Selesa Jaya, Taman Damai Jaya, Taman Danau, Taman Desa Jaya Bakti, Taman Desa Seri Menanti, Taman Industri Jaya, Taman Jaya Mas, Taman Melawati, Taman Nusa Bestari 2, Taman Nusa Bestari Jaya, Taman Nusa Jaya Mas, Taman Timur

Skudai Town is selected as a study area (see figure 1) because it is a rapidly expanding suburb of Johor Bahru, the largest city in and the capital of the state of Johor in southern Malaysia and also part of the new growth corridor of southwest Johor. The continued growth of the Iskandar Malaysia Region especially in the economics, transportation, institutional and other development also with the growth of the population rapidly consequently will attract more people to come and stay in Skudai and this give an effect to the trip generation in the Skudai Town.

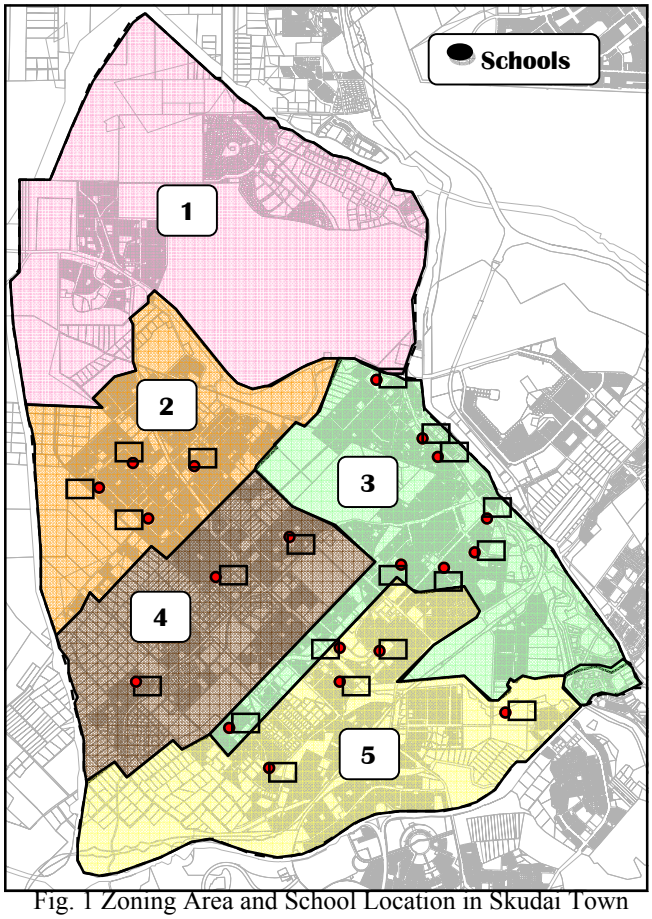

Fig. 1 Zoning Area and School Location in Skudai Town

B. Data Collection and Analysis

Primary school data compress of several data types whereas number of school, land area of school, total number of pupils in each school, and locations of schools. Data were obtained from education office, *Pejabat Pelajaran Daerah Johor Bahru (PPDJB)*. As shown in Table 1, there are 21 primary schools in Skudai Town with three types of schools which is national types, national types (Chinese) and national type (Tamil). Other data were obtained from local authority, Johor Bahru Central Municipal Council (MPJBT), report, development plan and internet.

TABLE I
LIST OF PRIMARY SCHOOL IN SKUDAI TOWN

No.	Schools Name	Acreage (Hectare)	School's Population
1	SK. Taman Universiti 1	3.064	933
2	SK. Taman Universiti 2	2.596	502
3	SK. Taman Universiti 3	5.572	562
4	SK. Taman Universiti 4	3.592	953
5	SK. Sri Skudai	3.474	812
6	SK. Skudai Bt. 10	1.655	510
7	SK. Taman Ungku Tun Aminah 1	2.426	599
8	SK. Taman Ungku Tun Aminah 2	1.687	586
9	SK. Taman Mutiara Rini 1	2.422	661
10	SK. Taman Mutiara Rini 2	2.106	674
11	SK. Taman Skudai Baru	1.382	413
12	SK. Taman Skudai Baru 2	1.586	456
13	SK. Taman Selesa Jaya	1.374	538
14	SK. Pendidikan Khas Johor Bahru	2.145	133
15	SK. Taman Damai Jaya	2.112	855
16	SJK (C) Kuo Kuang	3.371	4206
17	SJK (C) Kuo Kuang 2	0.265	4392
18	SJK (C) Pu Sze	1.092	2931
19	SJK (T) Taman Tun Aminah	3.096	1910
20	SJK (T) Ladang Rini	2.285	410
21	SK. Kg. Maju Jaya	0.313	718
	Total	47.928	9859

TABLE 1I
SUMMARY OF SCHOOL TRIPS DATA

Zones	2a	3a	4a	5a	6a	P
1	93	226	4	5	0	328
2	2744	40	108	1	2	2895
3	4	1988	235	363	1	2591
4	58	118	1304	153	0	1633
5	8	47	57	1366	0	1478
A	2907	2419	1708	1888	3	

C. Multiple Linear Regression Analysis

The regression model is employed to study the school trips per household in Skudai Town. In this regression model, three parameters are identified for this study. These parameters are accessibility, holding capacity and cost index for zones i. All of them are the main factors influence the school trips.

$$Yi = A_0 + A1X1i + A2X2i + A3X3i \quad (1)$$

Where: Y_i = School trips per household in zone i
X_{1i} = accessibility of zone i
X_{2i} = Holding capacity of zone i
X_{3i} = cost index of zone i
A_1, A_2, A_3 are regression coefficients
A_0 = Constant

Accessibility of Zone (X_1)

$$X_1 = \sum \{\text{No. Of schools in zone} / (\text{travel time from zone to zone of employment})^2\} \quad (2)$$

Holding Capacity of Zone (X_2)

$$X_2 = \text{present population} \times [(100 - \%\text{of zone i developed}) / \%\text{ of zone i developed}] \quad (3)$$

Cost Index of Zone (X_3)

$$X_3 = \{(\text{av. land value per hectare in residential zones}) / (\text{land value per hectare in zone i})\} \times 100 \quad (4)$$

School trips per household in Zone (Y_i)

$$Y_i = \{(\text{school trip per zone}) / (\text{dwelling unit per zone})\} \quad (5)$$

TABLE III
DATA OF EACH ZONE

Zone	Dwelling units per zone a	School Population Per zone b	School Trip per zone c	School Trips per household d = c / a Y_i
1	3504	328	656	0.187
2	29680	2895	5790	0.195
3	9475	2591	5182	0.547
4	20660	1633	3266	0.158
5	7095	1478	2956	0.417

TABLE IV
COEFFICIENT OF EACH PARAMETER FOR RESIDENTIAL ZONE

Zone	Y_i	X_{1i}	X_{2i}	X_{3i}
1	0.187	3.5	1181.2	113
2	0.195	0.4	3151.4	97.0
3	0.547	1.1	5431.9	97.6
4	0.158	0.7	2816.2	99.3
5	0.417	1.2	1250.7	100.7

Table III shows the data of dwelling unit, school population, school trip and school trips per household in each zone. This data are used to calculate the coefficient of each parameter for each residential zone i. The result is shown in Table 4.

TABLE V
REGRESSION COEFFICIENT AND STATISTICAL TEST

t	-4.629	-2.114	4.672	4.6599
Coefficient	-0.169	-7.41482E-05	0.811	16.566
Std. error	0.0365	3.50694E-05	0.1736	3.555
R^2	0.9677	0.0619	#N/A	#N/A
F	9.9869	df = 1	#N/A	#N/A
ssreg	0.1148	0.0038	#N/A	#N/A

Model Equation

$$Y_1 = 16.57 + 0.811X_1 - 0.00074X_2 - 0.169X_3$$

IV. Findings

It may be inferred from Table 5 that the school trips value (y-axis) or constant value of this model is positive (16.57) with the R^2 value is 0.96. The coefficient of determination R^2 compares estimated and actual y-values, and ranges in value from 0 to 1. If it is 1, there is a perfect correlation in the sample — there is no difference between the estimated y-value and the actual y-value. At the other extreme, if the coefficient of determination is 0, the regression equation is not helpful in predicting a y-value. The F statistic is used to determine whether the observed relationship between the dependent and independent variables occurs by chance, F (9.98) > 4.0 suggesting that the relationships did not occur by chance. The t-values are greater than 1.85 suggesting that each slope coefficient is useful in estimating the school trip generation per household. Thus this model is acceptable for Skudai Town trip generation. The value of accessibility is the highest shows that accessibility is the most affected factor of school trip generation in Skudai Town while holding capacity is less affected factor of school trip generation in Skudai Town. This result of trip generation of primary school trip generation in Skudai Town is useful for the further study on trip distribution, mode choice and trip assignment in order to forecast the travel demand for Skudai Town.

V. Conclusions

Trip generation in many studies has often determined by way of home based productions tied to income, family size and car ownership. In this study, trip generation was based on school on attraction because primary school attendance is compulsory irrespective of income level family size or car ownership. In the light of the discussion so far it can be concluded that: i) Estimating school trip generation based on attraction is effective, because primary school attendance in mandatory, ii) Estimating school trip generation based on attraction is efficient because information about trip generation can be disseminated quickly, iii) Since the primary focus is school trip making pattern, the assertion that schools could be relied upon for modeling trip generation is valid

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