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TRIP GENERATIONS AT "POLYCLINIC" LAND USE TYPE IN JOHOR BAHRU, MALAYSIA

ABSTRACT

Transportation planners need to estimate the trip generations of different land use types in the travel demand forecasting process. The Trip Generation Manual of Malaysia, similar to the Trip Generation Manual of the Institute of Transportation Engineers, USA, provides the trip generation rate at "Polyclinics" as a function of the Gross Floor Area. However, the data for this rate have no line of best fit resulting in the lack of confidence in the prediction. This study considered ten locations in Malaysia and verified the significance of different parameters, i.e. Number of Doctors, Number of Staff, Gross Floor Area and Density of Similar Clinics within 0.5 kilometre radius in Johor Bahru, Malaysia. The study developed regression equations for estimating the peak hours and daily trips at polyclinics in terms of "Number of Doctors". The developed models can be used in estimating the number of trips generated by the polyclinics in Johor Bahru, Malaysia.

KEY WORDS

polyclinic trip generation; polyclinic trip rates; local trip rates; Johor Bahru – Malaysia trip generation;

1. INTRODUCTION

Johor Bahru, located at the tip of the southern peninsular, just north of Singapore, is the second largest city of Malaysia. The geographical location of the area makes it an economic hub resulting in a rapid growth of the human as well as the vehicle population. The number of polyclinics in the city mushroomed during the last decade to meet the increased demand due to the human population growth. In Malaysia, the poly-

clinics are common health care facilities that provide outpatient pediatric and maternity care services but lack major surgical facilities which are generally associated with hospitals.

The Institute of Transportation Engineers (ITE) is an international body of transport professionals based in Washington, DC, USA, that publishes and updates the information regarding the trip generation for various types of land uses in USA. The Trip Generation Manual (9th Edition), 2012 [1] is the latest version that includes 172 different land use types. Though many studies have been conducted in different countries on trip generation rates, the ITE Trip Generation Manual is considered to be the most comprehensive document on trip generation. The Highway Planning Unit of the Ministry of Works Malaysia published the Trip Generation Manual Malaysia 2010 [2] that provides trip generation information on 61 different land use types in Malaysia. The Trip Generation Manual of the Institute of Transportation Engineers (ITE), USA [1] and The Malaysian Trip Generation Manual [2] estimate the number of trips as a function of the type of the development (land use type) and correlates these with the standard and easily measurable parameters that usually represent the characteristics of the sites, for example, square footage (GFA), number of dwelling units, number of filling points at a petrol station. The reliability of these forecasting rates influences the basic trip generation step of the four-step travel demand forecasting process. The traffic impact assessment of a given land use also depends on the accuracy of the data provided in the trip generation manuals. The above two documents are widely used as reference guide books for estimating trip generation rates for dif-

ferent land use types in Malaysia including the "Polyclinics".

The 2010 edition of the Malaysian trip generation manual with land use type CODE 02 03 05/06/12 [2] assumes that Polyclinics, Government Health Centres, and Clinics generate the same number of trips and a single rate is used for forecasting the trips generated by these land uses. However, this may not be true because the database for this rate does not provide any coefficient of determination value (R^2) or line of best fit. The lack of fitness of data in the Malaysian Manual might be due to insufficient number of data points considered, as only seven (07) to ten (10) data points have been considered for analysing trips generated by three different (similar but not the same) land use types, i.e. Polyclinics, Government Health Centres and Clinics altogether, or the selected independent variable (Gross Floor Area) was expected to explain the variation of the trips generated by the above land use group. This makes it difficult for transportation professionals in Malaysia to confidently assess the traffic impacts of any proposed polyclinic as the rate may lead to under-estimation or over-estimation of the number of trips generated by the "Polyclinic" land use type in the transportation planning process. In the study area, a typical polyclinic had a Gross Floor Area less than 100 square metres with a typical dimension of 5 metre by 10-20 metre that is much smaller than an average polyclinic size considered in the Malaysian Trip Generation Manual and the ITE Trip Generation Manual Land Use CODE 630.

Various research studies on trip generation have shown that trip rates available from trip generation manuals were not very much suitable for application in certain regions or states of a country due to differences in the socio-economic conditions. In forecasting trip generation by land use types, D.C Schoup (2002) [3] reported that transportation engineers and urban planners often report uncertain estimates as precise numbers, and unwarranted trust in the accuracy of these precise numbers can lead to bad transportation and land-use planning. This is because trip forecast made using models developed on national data do not give accurate number of trips generated because the sources of the rates do not reflect the variations in density, diversity (land use mix), site design, and the multimodal transportation systems in metropolitan areas, which are critical factors in travel demand [4]. In 2001 a verification of national trip generation rates as a representation of the local conditions was conducted by Evansville Urban Transport Study (EUTS) [5] in USA, where a list of five land use types were selected for this verification. The result showed that there was a great difference between the trip generation rates obtained by EUTS when compared with ITE trip generation rates

(7% to 70% difference). Also, a similar study conducted in Beijing [6] showed that traditional forecasting methods underestimate the number of trips generated from one zone to another. Furthermore, a recent study conducted at the University of Kansas [7] on the establishment of a local trip rate showed that the ITE rates overestimated the trips generated by each of the studied sites. This indicates that there is need for similar studies in Malaysia to verify the data available in the trip generation manuals for the rates for the local application. The above studies clearly support the idea that every land use type in each state or region should have its local rate of estimating the number of trips generated by that land use and discourage the application of national data in estimating trip generation. Therefore, similar studies should also be conducted in Malaysia to verify the use of its National trip generation Manual for local application since the Malaysian trip generation manual was developed from sites surveyed in only five (05) out of the thirteen (13) states in Malaysia with Johor Bahru not being among the states which were surveyed.

The main objective of the study was to collect trip generation data at ten (10) polyclinics in Johor Bahru, Malaysia and to identify the significant parameters affecting the number of trips generated, and to develop mathematical relationships between the trips generated and the significant parameters affecting the trip generation for the AM peak, PM peak and on a daily basis for the studied land use type. The study considered only non-24 hour operational "Polyclinics" using the methods of data collection provided in the ITE Manual of Transportation Engineering Studies [8].

The selection of the variables used in predicting trip generation rates has long been an area of concern for transport planners. For example, household trip generation variables include family size, number of households, vehicle ownership, and income level. These variables are generally selected based on the hypothesis that the social circumstances in which individuals live should have a considerable bearing on the opportunities and constraints they face in making activity choices, which later in turn may lead to different travel behaviours [9]. Considering the above, the purpose of this study was to verify the significance of other potential variables in addition to the previously considered parameter - "Gross Floor Area", in developing trip generation rates of "Polyclinics" that can be used in estimating the trips generated by this land use type in Johor Bahru, Malaysia or in any similar environment. The studied variables in this study were a) Gross Floor area, b) Number of Doctors, c) Number of Staff and d) Density of Similar Clinics within 0.5 kilometre radius; in determining the number of trips generated at AM peak hour, PM peak hour and on a daily basis. The surveyed locations with details are shown in *Figure 1*.

2. METHODOLOGY

The most widely used technique worldwide for estimating trip generation rates is the linear regression analysis. This is because models which depend linearly on their unknown variables are easier to fit than models which are non-linearly related to the variables, and because the statistical properties of the resulting estimators are easier to determine [10]. At the beginning of this study, details related to the surveyed sites were obtained through direct measurements and interviews with the owners or the receptionists of the Polyclinics. The interviews provided the information on the number of practicing doctors (serving in general), total number of working staff, days and hours of operation in a week, etc. Directional traffic volumes entering

and exiting the study site by 15-minute interval were counted manually for the whole operating hours of the Polyclinics surveyed for two (2) consecutive days, i.e. on a typical working day (Tuesday-Thursday) and on Saturdays for the weekend count. The morning (AM) and evening (PM) peak hours of the generator were extracted from a plot of the daily traffic volume variation against time of the day. The peak hour of the generator is the highest combined one-hour of traffic volume entering and exiting the polyclinic which may not correspond to the peak hour of the adjacent street (commuter).

Two methods of analysis were considered in estimating the trip generation rate; they are weighted average trip generation rate and linear regression analysis using MS Excel on each of the four independent

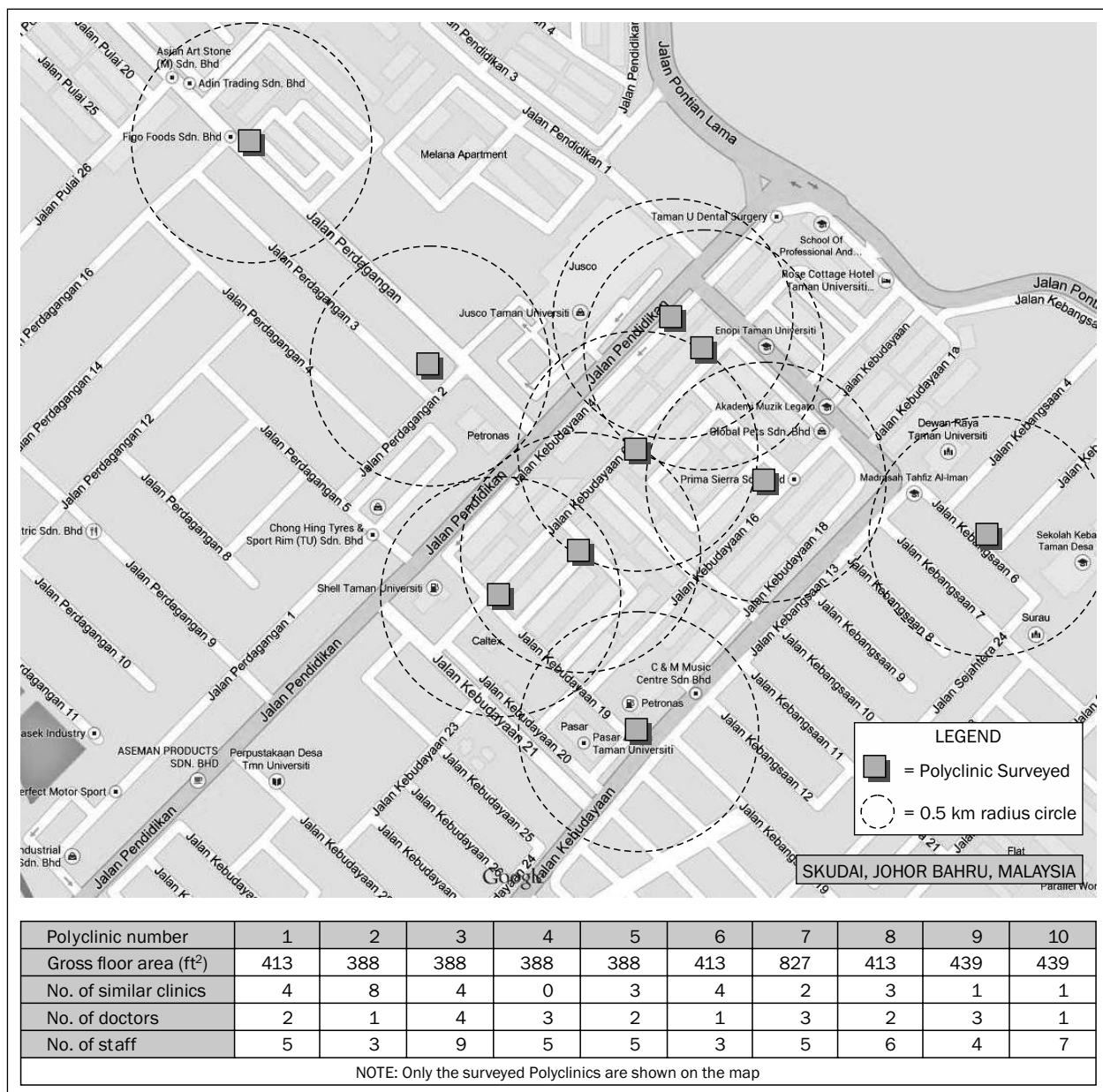


Figure 1 - Locations and details of the surveyed polyclinics in Johor Bahru, Malaysia

Table 1 - Summary of data collected during the interview, measurement and traffic volume count.

SITES	Independent Variables				Trips Generated		
	GFA (TSF)*	Number of Doctors	Number of Staff	Density of Similar Clinics within 0.5 km	AM Peak Hour	PM Peak Hour	Daily
1	0.413	2	5	4	24	9	103
2	0.388	1	3	8	7	4	18
3	0.388	4	9	4	30	19	135
4	0.388	3	5	0	38	28	175
5	0.388	2	5	3	17	16	74
6	0.413	1	3	4	15	3	53
7	0.827	3	5	2	24	20	78
8	0.413	2	6	3	15	8	37
9	0.439	3	7	1	27	13	129
10	0.439	1	4	1	13	9	58
	Sum				210	129	860
	Percentage In/Out				56/44	51/49	52/48
	Standard Deviation				9.26	6.50	48.95

Table values of 't' for 8 and 7 degrees of freedom at 5% level of significance are 1.86 and 1.90, respectively.

*GFA: Gross Floor Area per 1,000 square feet (TSF) equivalent to 92.9 Square Metres

variables selected. The relevant tests were conducted to assess the goodness of the fits of the models based on the statistical analyses.

Furthermore, trip generations at other two separate polyclinics were counted and were used in validating the developed regression equations and to estimate the forecasting errors of the models and to compare those with the forecasting errors of the Malaysian and the ITE Trip Generation data.

3. FINDINGS OF THE ANALYSIS

A summary of the data obtained from the interviews and traffic volume counting is shown in Table 1.

A plot of the variation of daily trips generated by the Polyclinics with time of day at each of the surveyed sites provided the information that the morning peak hour of the generator (peak demand at the polyclinics occurred between 9:30 - 11:30 a.m. and the PM peak hour between 2:00 - 4:00 p.m.

4. AM PEAK HOUR TRIP GENERATION ANALYSIS

Scattered diagram and inter-correlation matrix were used to examine the nature of the relationship between the dependent variable and each of the independent variables; the result showed that only the Number of Doctors and Density of Similar clinics were correlated to the morning peak hour trips generated by the polyclinics. Three separate regression analyses were performed as follows:

- A. AM peak hour trips as Y and the number of Doctors as X_1 ,
- B. AM peak hour trips as Y and Density of Similar Clinics within 0.5 km as X_2 , and
- C. A multiple regression analysis combining the two independent variables X_1 and X_2 above.

The results of the PM peak hour analyses are shown in Table 2 and Figure 2.

Table 2 - Models developed for AM Peak Hour

R^2	S_e	t-statistic	
		X_1	X_2
$Y = 4.5 + 7.5X_1$ (1)			
0.70	5.58	2.15	0.70
$Y = 28.43 - 2.48X_2$ (2)			
0.36	7.82	---	0.36
$Y - 11.14 + 6.36X_1 - 1.37X_2$ (3)			
0.80	4.75	3.83	0.80

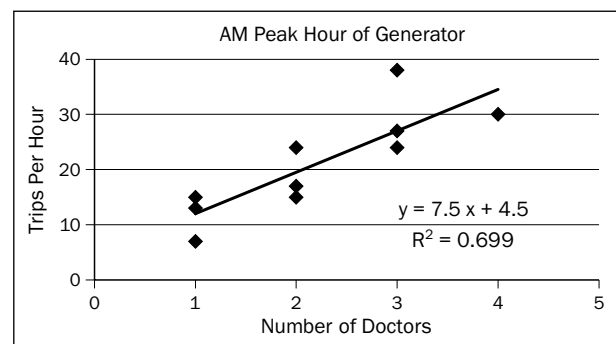


Figure 2 - Selected AM Peak Hour Model

Equation 1 has a reasonable R^2 value, and its standard error S_e (5.58) is less than the standard deviation (9.26). Also the sign of the partial regression coefficient is having an increasing effect on the number of trips generated and the t-value of X_1 is greater than the table value of t, therefore, this model satisfies the logical and the statistical checks, and is therefore considered acceptable.

Equation 2 has R^2 value less than 0.5 and the intercept constant is very large, therefore model B is rejected. Model C has the best R^2 value (0.8), and the signs of the partial regression coefficients are logical but the value from the t-test for X_2 is less than the table value of t (1.81 < 1.90). This implies that the independent variable X_2 is not significant in explaining the variations of dependent variable, therefore, there is no point of having it in the regression equation. Hence, the regression equation should be in terms of X_1 only (which is Equation 1).

5. PM PEAK HOUR TRIP GENERATION ANALYSIS

The results from the inter-correlation matrix show that only the Number of Doctors and Density of Similar Clinics are correlated to PM peak hour trips observed and these independent variables have been used in developing the regression equations. Gross Floor Area and the Number of Staff were less correlated with the PM peak hour trips (having a correlation value below 0.5) and therefore will not be used in the regression analysis. Three separate regression analyses were performed as follows:

- A. PM peak hour trips as Y and number of Doctors as X_1 ,
- B. PM peak hour trips as Y and Density of Similar Clinics within 0.5 km as X_2 , and
- C. multiple regression analysis combining the two independent variables X_1 and X_2 above.

The results of the PM peak hour analyses are shown in Table 3 and Figure 3.

Table 3 - Models developed for PM Peak Hour

R^2	S_e	t-statistic	
		X_1	X_2
Y = 0.08 + 5.42 X_1 (4)			
0.74	3.50	4.78	-----
Y = 17.02 - 1.67 X_2 (5)			
0.34	5.60	-----	2.03
Y = 4.22 + 4.7 X_1 - 0.86 X_2 (6)			
0.82	3.15	4.28	1.70

From the Table, Equation 4 is found to be the best when compared with Equation 5 and Equation 6 because it satisfied all the statistical and logical checks.

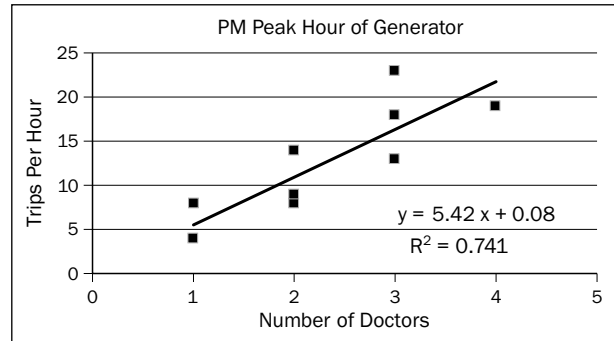


Figure 3 - Selected PM Peak Hour Model

Equation 5 was considered as failed because it could only explain 34 percent of the PM trips generated by the Polyclinics, and a relatively high intercept constant was noticed. Equation 6 has the best R^2 value but it fails in the t-test since the t-value for X_2 (1.70) is less than the table value of t (1.90) which indicates that the independent variable X_2 is not significant in the regression analysis, and as such the regression should only be in terms of X_1 .

6. DAILY TRIP GENERATION ANALYSIS

Results of the inter-correlation matrix showed that only the Number of Doctors and Density of Similar Clinics are correlated to the daily trips generated by the polyclinics and thus these parameters were used in the regression analyses. Three separate regression analyses were performed as follows:

- A. daily trips generated as Y and number of Doctors as X_1 ,
- B. daily trips as Y and Density of Similar clinics within 0.5 km as X_2 , and
- C. multiple regression analysis combining the two independent variables X_1 and X_2 above.

The results of the Daily Trip analyses are shown in Table 4 and Figure 4.

Table 4 - Models developed for Daily Trips

R^2	S_e	t-statistic	
		X_1	X_2
Y = 5.6 + 36.56 X_1 (4)			
0.60	33.04	3.43	-----
Y = 124.86 - 12.96 X_2 (5)			
0.36	41.6	-----	2.11
Y = 42.86 + 30.13 X_1 - 7.72 X_2 (6)			
0.70	30.22	2.86	1.60

Considering the R^2 value of Equation 8 and the significance of X_2 in Equation 9, both models have failed in satisfying the statistical checks and therefore have been rejected. However, Equation 7 is having a

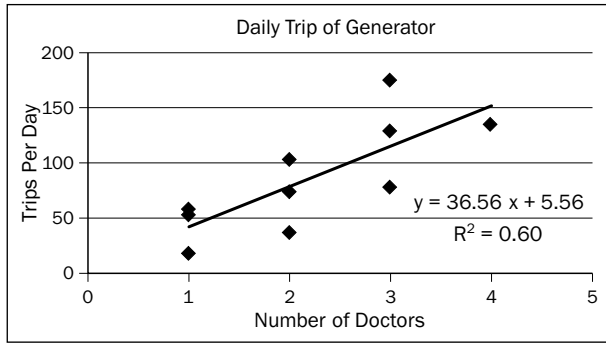


Figure 4 - Selected Daily Trip Model

reasonable intercept constant, and is able to explain 60% of the variations of the dependent variable and the model satisfied the statistical and logical tests, and was accepted.

7. WEIGHTED AVERAGE TRIP RATES

A second analysis was conducted in terms of average trip rates for the Daily, AM and PM Peak Hour trips. This was developed to serve as an alternative to the regression equations in estimating the trips. The result shows that the standard deviation of the weighted average trip rates is relatively higher than the standard error in the regression analysis.

7.1 Comparison of polyclinic trip generation rates

The trip generation rates obtained from this study were compared with the ITE Trip Generation Manual [1] and the Malaysian Trip Generation Manual [2] for the "Polyclinic" land use type and the results are shown in Table 5.

Table 5 - Comparison of Polyclinic trip generation rates obtained from this study with the ITE Trip Generation and the Malaysian Trip Generation Manuals

Source	Per	Daily Trip rate	AM Peak	PM Peak
ITE	TSF of GFA	31.45	NA	5.18
Malaysian	TSF of GFA	48.63	8.87	5.45
This Study	No. of Doctors	$Y = 5.6 + 36.56x$	$Y = 7.5x + 4.5$	$Y = 5.416x + 0.083$

TSF GFA - Thousand Square Feet (TSF) of Gross Floor Area (GFA) equivalent to 92.9 square metres of the polyclinic, NA - Not Available.

Table 6 - Model Validation and Determination of Forecasting Error in the Model

Site No.	Independent Variables		Observed No. of Trips			Malaysian Manual			This Study			ITE	
	GFA (TSF)*	No. of Doctors	AM	PM	Daily	AM	PM	Daily	AM	PM	Daily	PM	Daily
1	0.388	1	15	7	32	3.44	2.15	18.87	12.0	5.48	42.16	2.01	12.2
2	0.439	2	22	10	52	3.89	2.39	21.34	19.5	10.92	47.76	2.27	13.8
Average forecasting error in Percentage						79.7	72.7	50.00	15.68	6.28	-11.8	88.1	67.66

*GFA: Gross Floor Area per 1000 square feet (TSF) equivalent to 92.9 Square Meter.

From Table 5 it is visible that while the Malaysian Trip Generation Manual provides the rates for Daily, AM and PM peak hour trips, the ITE Manual does not provide information on the AM peak hour trip generation.

7.2 Model validation

Validation of the models was conducted and the results are shown in Table 6.

The analysis showed that the predictive errors of the models developed in this study are less than those of the Malaysian Manual and ITE Trip Generation Manual. This might be due to the socio-economic variations, difference in land use characteristics, or the pattern of living in this region. The Malaysian Trip Generation Manual and the ITE Trip Generation Manual do not consider that the number of patients in the polyclinics will be related to the number of doctors serving the facility. Basically, it is assumed that the demand will be correlated to the size of the facility. However, in the local environment of Johor Bahru, Malaysia, the number of patients or the trips generated by the patients are practically related to the service availability from the polyclinics and the important parameter governing that is the Number of Doctors and the availability of the doctors appointments. It is logical to predict the trip generation of polyclinics in terms of the Number of Doctors since the patients look for the quality of service received and less delay and smaller queues to receive the service from the polyclinics rather than the size of the building.

8. CONCLUSION

This study revealed that the Malaysian Trip Generation Manual underestimates the number of trips gen-

erated by the "Polyclinic" land use type in Johor Bahru, Malaysia. This study provided a better possibility of determining the trip generation rates of the "Polyclinic" land use type in Johor Bahru, Malaysia. The outcome of the study shows that the Gross Floor Area is not the best parameter in estimating the trips generated by the polyclinics in Malaysia. This might be one of the reasons why the polyclinic trip generation rates in the Malaysian Trip Generation Manual are lacking in the line of the best fit and show weak correlations with small R² values. Out of the four independent variables considered in this study, the "Number of Doctors" was found to be the most significant in determining the number of trips generated by the polyclinics in Johor Bahru.

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