MODELING HOUSEHOLD TRIP GENERATION FOR SELECTED ZONES AT AL-KARKH SIDE OF BAGHDAD CITY

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ABSTRACT

Trip generation is the first phase in the travel forecasting process. It involves the estimation of the total number of trips entering or leaving a parcel of land per time period (usually on a daily basis); as a function of the socioeconomic, locational, and land-use characteristics of the parcel.

The objective of this study is to develop statistical models to predict trips production volumes for a proper target year. Non-motorized trips are considered in the modeling process. Traditional method to forecast the trip generation volume according to trip rate, based on family type is proposed in this study. Families are classified by three characteristics of population social class, income, and number of vehicle ownership. The study area is divided into 10 sectors. Each sector is subdivided into number of zones so; the total number of zones is 45 zones based on the administrative divisions. The trip rate for the family is determined by sampling. A questionnaire is designed and interviews are implemented for data collection from selected zones at Al-Karkh side of Baghdad city. Two techniques have been used, full interview and home questionnaire. The questionnaire forms are distributed in many institutes, intermediate, secondary and, commercial schools. The developed models are total person trips /household, work trips /household, education trips/household, shopping and social/recreational trips/household and, person trips/person. These models are developed by using stepwise regression technique after the collected data being fed to SPSS software.

Results show that total persons trips/household are related to family size and structure variables such as number of person more than 6 year age, number of male, total number of workers, total number of students in the household, number of private vehicles. This model has coefficient of determination equal to 0.669 for the whole study area. Also the results show that the home-based work trips are related to number of worker in the household, number of male workers in the household, number of female workers in the household and number of persons of (25-60) year age; this model has coefficient of determination equal to 0.82 for the whole study area. Home-based education trips are strongly related to number of students in the household and this model has coefficient of determination equal to 0.90 for the whole study area.

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Key Word: - Household, Modeling, Trip Generation, Travel Demand.

INTRODUCTION

Urban transportation planning is the process which represents the integration of many interacting characteristics of the urban environment (Brain et al, 1974). It is carried out to develop a program of high way and transit projects that should be completed in the future. As motorization is progressed, it has become increasingly evident that the traffic congestion "problem" cannot be solved by building more road infrastructure.

Forecast of demand for the system at the various levels of facility provision considered is one of the basic elements of long-term transportation planning. It is consist of the following steps (Wright, 1998):

1. Population and economic analysis.
2. Land use analysis.
3. Trip generation.
4. Trip distribution.
5. Mode choice (or model split).
6. Traffic assignment.

Population and economic activity predictions generally are derived by specialist demographic and economic projections outside the scope of the transportation study.

There has been considerable debate on the land use. A number of models have been developed that relate changes in land use to such independent variables as: accessibility to employment, land value, intensity of land use …etc (Wright, 1998).

The population of Baghdad urban area according to the previous census is given in Table 1, whereas Fig.1 is illustrate the land uses for Baghdad city.

The four remaining steps are of considerable interest and the whole four steps are refer to as (Traditional Method) for prediction travel demand (Venigalla et al, 1999).

Trip generation involves the estimation of the total number of trips entering or leaving a parcel of land per time period (usually on a daily basis); as a function of the socioeconomic, locational, and land-use characteristics of the parcel. Usually multi-mode and purpose journeys are simplified into trip identified by a principal mode and purpose, ignoring intermediate stages and stops for secondary purposes (Hobbs, 1979). The reliability of forecasting results influences the following steps such as trip distribution, mode split, and traffic assignment. Therefore, improved trip generation models are needed to improve forecasting precision (Liya and Hongzahi, 2008).

Table 1 Population of Baghdad City (Ref. BCTS 1980, 1977 Census, 1987 Census, 1997 Census).

Census year	population
1947	666000
1957	785000
1977	2023242
1987	3841269
1997	4083258

The ultimate purpose of the trip generation analysis is to arrive at an estimate of the trip ends generated at each analysis unit of the study area.

Traditionally, trip generation forecasts are established independently of any direct consideration of the transportation network. This assumes that trips produced at or attracted to a zone are a function only of the attributes of the zone itself and are not directly a function of the transportation network on which the trips are made (NTL, 2006).

The study of trip generation attempts to identify and quantify the trip ends related to various urban activities without describing other trip characteristics such as direction, length or duration. Usually, the interest is in trips per average weekday, but may be for weekend or special purpose travel (FHWA, 1975).
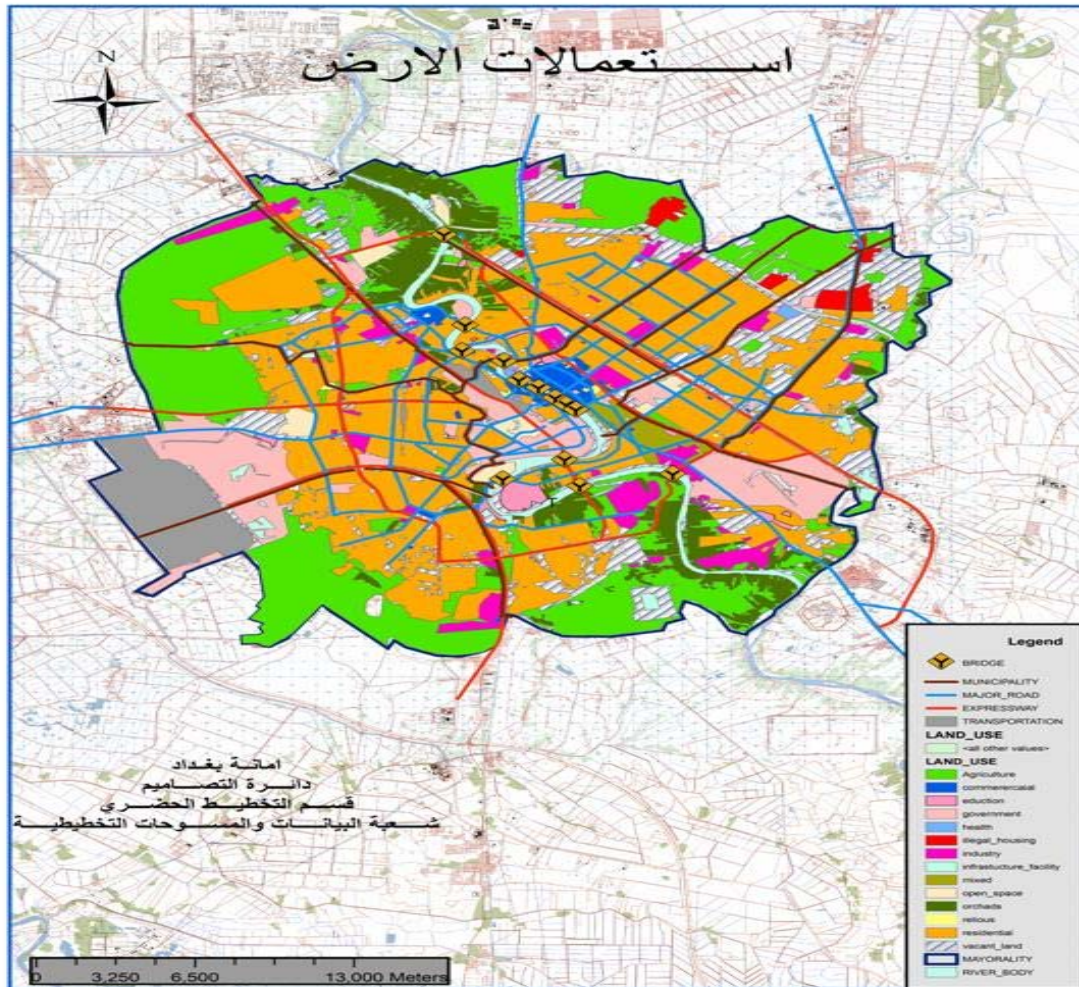
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Fig.1 Land Uses of Baghdad City

Methodology

The models start with defining the study area and dividing them into a number of zones and considering the entire transport network in the system. The database also includes the current (base year) levels of population, economic activity like employment, shopping space, educational, and leisure facilities of each zone.

The following steps are convenient to be followed:

-Selection and Zoning the study area.
-Design of the questionnaire form.
-Sample sizes calculation and selection
-Data collection and processing

1.0 Selection and Zoning the study area

The study area is bounded between the left bank of Tigris River and the external west boundaries of Baghdad city. The population of Al-Karkh urban area reached to 1,010,408 inhabitants in

1977 census and 1,365,057 inhabitants in 1987 census and 1,797,557 inhabitants in 1997 census (Census Results,1977),(Census Results,1987),(Census Results,1997).

Because of the mass of data collected relates to individual journeys, households and, centers of employment, and in its crude form, is difficult to analyze and interpret, the area being surveyed is divided into zones for the purpose of grouping the data so as to make it intelligible, amenable to analysis (Bruton, 1985).

The zoning procedure requires the division of the survey area into spatial units suitable as a basis for data collection, and later for aggregate analysis purposes. In certain cases, it may be desirable to set up two complete zoning patterns. The first of these would be the zoning pattern to be used in data collection , and would divided the area up to spatial unit best suited to be treated as individual element in sampling process. The

second set of zones would comprise the zones to be used for analysis purposes (Stopher, 1977). In large study area it is more convenient to divide the study area into sectors. The zoning system used in this analysis is based on the administration divisions shown in Fig.2. Study area zoning is shown in Fig.3

2.0 Design of the Questionnaire Form

Traditional household survey has five sections; dwelling unit information, household characteristics, car ownership characteristics, personal characteristics and, trip details (Mathew and Rao, 2007).

Dwelling unit characteristics; this section includes a set of questions designed to obtain information about the dwelling unit. Information includes:

Dwelling unit type

Dwelling unit ownership

Availability of garage

The Household characteristics; include

Average monthly income

Number of persons in the household (stratified into male and female)

Trip data; this part of the survey aims at detecting and characterizing all trips made by the household members include:

Number of trips

Purpose of each trip

Mode of trips

Origins and destinations of trips

Time of starting and ending of trips

Cost of trips

Purposes of trips considered here are work, education (school or college), shopping, social/recreational, change mode and, return to

Number of workers in the household (stratified into male and female).

Number of students in the household (stratified into male and female).

Number of persons less than school age

Number of persons in each age group

Car ownership characteristics; include:

Number of available cars

Type of each car

 Nature of use

Often, cars are classified according to type and size (BCTS, 1980), therefore cars are classified into private, taxi, bus, minibus, truck, pickup and, others.

Personal characteristics; this part includes questions designed to classify the household members (older than 6 year) according to the following aspects:

Gender, Age

 Profession

 Winning or official

 Educational level

Number of residence year

Location of the work or education

Time waiting the transportation mode in minute home. It may necessary to combine some of these purposes at modeling stage (BCTS, survey report, August 1980).

Travel modes used are:

Private (salon, taxi, bus, truck).

Government bus.

Taxi.

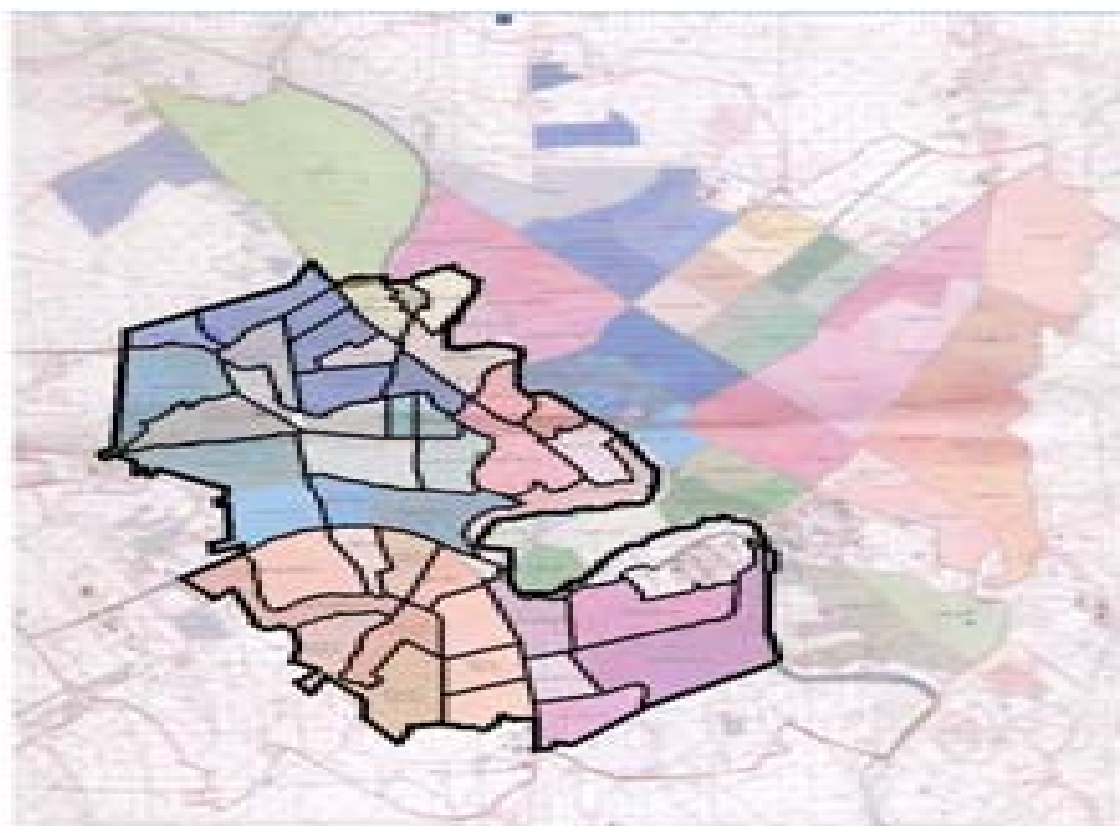Mini bus.

Bus.

Motor cycle

Bicycle.

Walking.

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Fig.2 Council Municipals of Baghdad City

Fig. 3 Study Area Zoning

Table 2 Sample Size for Home Interview Survey

Study Area Population	Sample Size	
	Minimum	Recommended
Under 50 000	1 in 10	1 in 5
50 000 –150 000	1 in 20	1 in 8
150 000 – 300 000	1 in 35	1 in 10
300 000 – 500 000	1 in 50	1 in 15
500 000 – 1 million	1 in 70	1 in 20
Over 1 million	1 in 100	1in 25

Table 3 Executed Samples

No. of sector	Executed size	Sample Rate
1	451	0.112300797
2	116	0.028884462
3	519	0.129233068
4	451	0.112300797
5	479	0.119272908
6	490	0.122011952
7	225	0.056025896
8	550	0.136952191
9	551	0.137201195
10	300	0.074701195
Total	4016	1

3.0 Sample Sizes Calculation and Selection

The methods used to calculate the sample size for this analysis are:

1. The National Committee on Urban Transportation (NCUT) Method: The method is recommended for conducting home interviews, sample sizes is given in the table above.

2. Smith formula method: smith formula specify the use of coefficient of variation in determining the sample size as shown in the following formula:

$$n = C.V^2 Z^2 / E^2 \qquad \text{eq.1}$$

Where C.V = coefficient of variation (For a given variables),

E = accuracy level,

Z = normal variants, and

n = number of samples.

Table 3 shows the executed sample for each sector in the study area.

4.0 Data Collection and Processing

The collection and processing of the Household Interview Survey data will follow a set of carefully considered and approved methods and procedures. To develop accurate trip production models, a large number of data is needed. Most of the necessary data are needed to relate the amount and character of urban activity. Typically, these data come from large-scale of household travel surveys and inventories of existing land-use characteristics. Census data are also a valuable source of information for transportation planners (Wallace and Shadoff, 1998) The methods used in home interview survey are:

a-Full interview technique: Involves interviewing as many members of the household as possible in directly recording all the information.

b-Home questionnaire technique: The interviewer collects details of the household characteristics leaving forms for household residents to be completed, regarding travel information. The completed forms are collected by the interviewer after day or two (Safa-Eldeen, 2006). This study uses two methods as shown in Table 4.

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Table 4 The Distribution of Types of Survey Methods

Sector No.	Full Interview		Questionnaire		Total	
	No.	%	No.	%	No.	%
1	١٨٧	٤١,٤٦	٢٦٤	٥٨,٥٤	٤٥١	100
2	٣١	٢٦	٨٥	٧٤	١١٦	100
3	١٩٣	٣٧,١٨	٣٢٦	٦٢,٨٢	٥١٩	100
4	١٥١	٣٣,٤٨	٣٠٠	٦٦,٥٢	٤٥١	100
5	١٠٠	٢٠,٨٧	٣٧٩	٧٩,١٣	٤٧٩	100
6	*٠	*٠	٤٩٠	١٠٠	٤٩٠	100
7	*٠	*٠	٢٢٥	١٠٠	٢٢٥	100
8	١٠٥	١٩,٠٩	٤٤٥	٨٠,٩١	٥٥٠	100
9	١٠١	١٨,٣٣	٤٥٠	٨١,٦٧	٥٥١	100
10	٤٤	١٤,٦٦	٢٥٦	٨٥,٣٤	٣٠٠	100
Total	٨٢٠	٢١,٩٣	3196	٧٨,٠٧	٤٠١٦	100

Development of Trip Production Models
The dependent and independent variables for this analysis are as follow:

Dependent Variables
Y = Total Persons trips/HH
Y_1 = Home-Base-Work trips
Y_2 = Home-Base-Education trips
Y_3 = Home-Base-Social/Recreational & Shopping trips
Y_p = Person trips /person

Independent Variables
1. Dwelling Unit Characteristics and Income
X_{101} = Dwelling unit type (House=1, other=0)
X_{102} = Dwelling unit Ownership (Owned=1, Rented=0)
X_{103} = Availability of Garage (Yes=1, No=0)
X_{104} = Household mean income in (ID 1000)
2. Household Size and Structure
X_{201} = Number of Males
X_{202} = Number of Females
X_{203} = Household size
X_{204} = Number of Male workers in the Household

X_{205} = Number of Female workers in the Household
X_{206} = Total Household workers
X_{207} = Number of Male students in the Household
X_{208} = Number of Female students in the Household
X_{209} = Total Household students
3. Household by Age Groups
X_{301} = No. of Person Less than (6) years
X_{302} = No. of Person (6 – 18) years
X_{303} = No. of Person (19 – 24) years
X_{304} = No. of Person (25 – 60) years
X_{305} = No. of Person more than (60) years
X_{306} = No. of Person more than (6) years
4. Vehicle Ownership
X_{401} = No. of Available Vehicles
X_{402} = No. of Private Vehicles
X_{403} = No. of Taxi Vehicles
X_{404} = No. of Other Vehicles
5. Person Characteristics
X_{501} = Age
X_{502} = Gender (Male =1, Female =0)
X_{503} = Education Level "Educated" (Yes=1, No=0)
X_{504} = Education Level "School[*]" (Yes=1, No=0)

X_{505} = Education Level "Collage or Institute" (Yes=1, No=0)

X_{506} = Profession Status (Work=1, Do Not Work=0)

X_{507} = Profession "Official" (Yes=1, No=0)

X_{508} = Profession "Winner" (Yes=1, No=0)

X_{509} = No. of Years in the Residence

X_{510} = Time waiting the transport mode in minute

X_{511} = Mode of Travel (Private) (Yes=1, No=0)

X_{512} = Mode of Travel (Taxi) (Yes=1, No=0)

X_{513} = Mode of Travel (Bus) (Yes=1, No=0)

X_{514} = Mode of Travel (Walk or biking) (Yes=1, No=0)

Prior to model development, there are many steps should be carried out. These steps are followed in this study and shown graphically in the figure 4 below:

Test Variables for Multi-co linearity

Table 5 represents the partial correlation matrix controlling for Y for the whole data of Al-Karkh.

If the correlation coefficient between two variables is high, then one variable has the larger correlation coefficient with the dependent variable should be included in the models but not both the variables. For example, by inspecting Table 5 the correlation coefficient between number of female (X_{202}) and number of female student per household(X_{208}) is 0.606 and the correlation between total trips/HH and X_{202} and X_{208} are 0.507 and 0.434 respectability therefore only X_{202} should be included in the model.

Error Tests

The distribution of error must be normal. This assumption can be tested by normal probability plot. If 95% of points lies in the range (-2,2) then the errors are normally distributed. Fig. 5 shows the 45 line plot of errors for whole data of the study area. It can be noted that the points lies between the range of (0,1) and errors are normaly distributed.
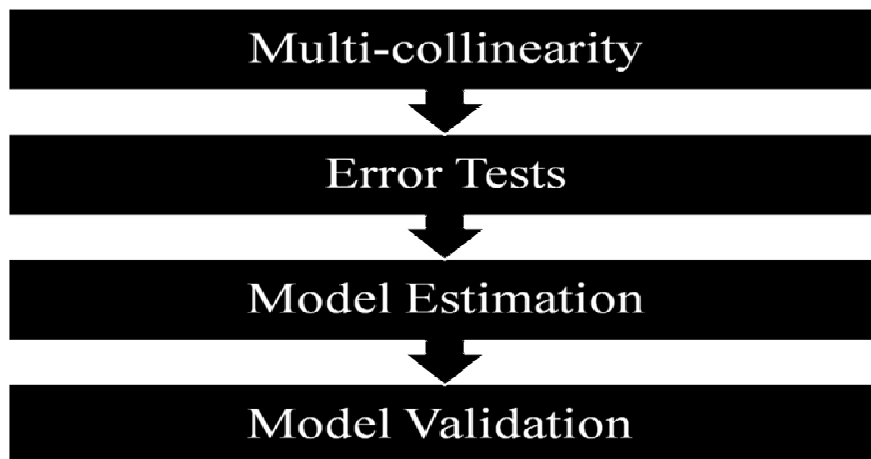

Fig.4 Statistical Methodology for model estimation

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Table 5 Partial Correlation Matrix Controlling for Y

| variables	X_{104}	X_{202}	X_{205}	X_{208}	X_{301}	X_{303}	X_{304}	X_{306}	X_{401}	X_{402}	X_{403}
X_{104}	1										
X_{202}	-0.071	1									
X_{205}	0.303	0.008	1								
X_{208}	-0.161	0.606	-0.124	1							
X_{301}	0.006	0.519	-0.064	0.258	1						
X_{303}	-0.024	0.324	-0.089	-0.105	-0.023	1					
X_{304}	0.139	0.125	0.064	-0.079	0.362	-0.091	1				
X_{306}	0.167	0.184	0.077	-0.188	0.345	0.158	0.015	1			
X_{401}	0.284	-0.030	0.087	-0.058	0.024	0.029	0.069	0.127	1		
X_{402}	0.280	-0.019	0.104	-0.016	-0.008	-0.004	0.052	0.097	0.839	1	
X_{403}	-0.019	0.010	-0.022	-0.040	0.032	0.073	0.029	0.009	0.134	-0.126	1
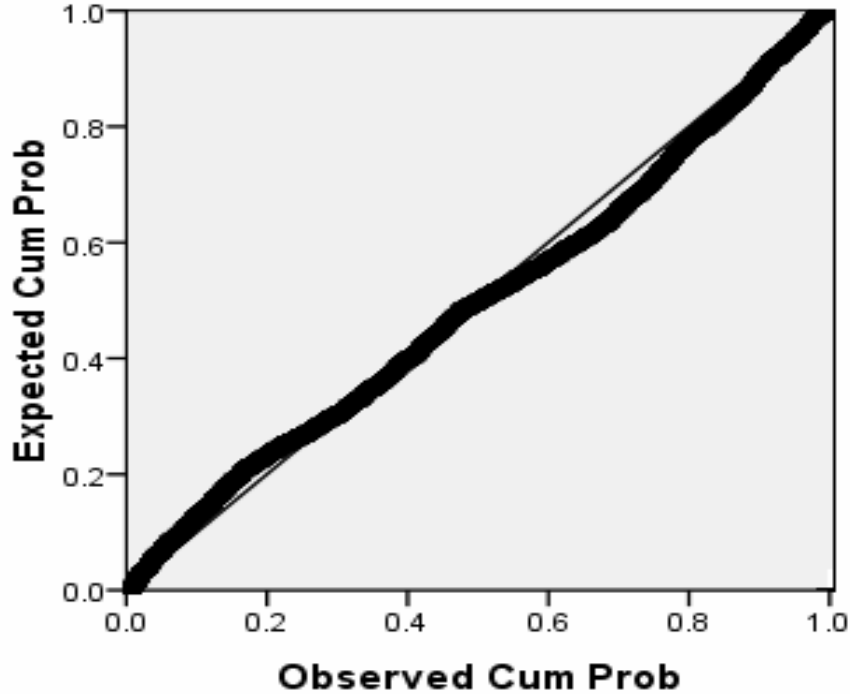
Fig. 5 45 line Plot of Errors

Models Estimation

Many methods of linear regression are available, they are:

Enter, Stepwise, Remove, Backward, Forward
The best and commonly method used to determine parameter of prediction model is

stepwise method (Abed, 2010). This method computes the simple regression model for each independent variable. The independent variable that has the largest F-statistic is chosen as the first entering variables. If at least one variable exceeds the standard, the procedure continues. The procedure considers whether the model will be improved by adding a second independent variable and so on. It examines all variables to .

determine which has the F-statistic which suite the selected F-statistic to enter criteria (Al-Zaidy, 2005). Either F value or probability of F are used as enter criteria. Probability of F equal to 0.05 is used in the analysis, this correspond to 3.84 F value.

Table 6 shows the resulted models with coefficient of determination R^2 for whole data of the study area

Table 6 Stepwise Regression Results for Y

Dependent Variable	Models	R^2
Y	$3.019+1.362X_{306}+0.758X_{209}+0.493X_{206}+0.356X_{201}+0.243X_{402}$	0.669
Y1	$0.182+0.478X_{206}+1.194X_{204}+1.26X_{205}+0.08X_{304}+0.035X_{303}+0.07X_{305}$	0.82
Y2	$0.378+1.792X_{209}$	0.900
Y3	$2.789+0.13X_{203}+0.243X_{201}-0.533X_{205}+0.326X_{103}+0.23X_{303}+0.362X_{304}-0.452X_{204}+0.352X_{305}+0.182X_{401}-0.202X_{102}$	0.089
Yp	$0.43+1.034X_{502}+0.283X_{505}+1.297X_{514}+1.141X_{513}+1.128X_{511}+1.097X_{512}+0.003X_{501}+0.353X_{504}$	0.478

Conclusions

Major conclusions found in the trip production analysis are that the first model (Y) is the preferred from the rest models because of the preferred statistical results and the simplicity of the application. On the other hand, purposes trip models (Y1, Y2, and Y3) cannot be use in application because all purposes trips models must be applicable to use. Work and education trip models are good from the statistical point of view, while shopping and social/recreational trip models are poor from the statistical point of view. Whereas person trip models (Yp) are weak. It may be due to the non linear relationship between Yp and person's variables.

Other conclusions found are:

1. Most of the household variables have statistically significant relationships to each trip purpose, apparently due to multiple collinearities between a household's numbers of person's workers, and vehicles.

2. In general, the strongest single predictor of trips in a given purpose is the number of persons eligible or most expected to make such trips. For work trips, this is the number of employed persons; for education trips, it is the number of school-age children and persons in a college age group. For shop and other trips, this is simply the

number of persons counted as trip makers such as number of male, number of female workers per household.

3. The most effective independent variables on total trips/HH are household size variables, from these variables the most notable effect is number of person more than 6 year. The most effective independent variables on person trips/person are gender and modes of travel.

4. In many models the constant and income parameters have (t) value less than 2 and hence these parameters are insignificant. Therefore, the constant and income are eliminating from these models.

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