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The influence of urban physical form on trip generation, evidence from metropolitan Shiraz, Iran

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Abstract

This paper aims to examine the relationship between urban form and personal daily trips between urban zones across Metropolitan Shiraz, Iran. To cope with collinearity nature of trip generation determinants and also multicollinearity in model estimation, component principal analysis (PCA) was employed to identify latent dimensions of trip generation. Then, a multiple regression model with continuous independent variables was developed to measure the effect of each individual variable on entire trips generated among urban zones. The explanatory variables included both physical characteristics of the metropolitan (land use diversity, density, suburbanization, connectivity, and accessibility to public transport), and socio-economic characteristics of trip makers (age, employment status, education, migration, property value) aggregated on the urban zones scale. The empirical findings, based on ordinary least squares (OLS) estimation of 2006 data for 47 traffic area zones (TAZ) with total population over 1.1 million indicated that socio-economic characteristics were the most positive determinants of trip generation among the zones. On contrast, suburbanization (distance from central business district (CBD)) and distance from public transport facilities were negatively associated with the trip generation. However, other physical factors such as land use mix and network connectivity were found not important in influencing intra-zone trip generation, probably influencing inter-zone trip generation instead. In fact, improving local accessibility may reduce the need to intra-zonal travel, rather may also increase the tendency to travel within the neighborhood area.

Keywords: Urban transport, urban planning, trip generation, metropolitan Shiraz, Iran.

Introduction

Trip generation is the prediction/determination of the volume of trips produced by and attracted to a geographical district (TRB, 2011; Ben-Edigbe & Rahman, 2010). There is considerable current interest in investigating the effects of urban structure and land use characteristics on the volume of travel made by urban residents (Williams, 2000; Cervero & Duncan, 2006; Greenwald, 2006; Fadare, 2010). The underlying assumption is that urban form and structure characteristics play an influential role in affecting the necessity of travelling. Smart distribution of urban activities could provide residents essential services and facilities in a reasonable distance thus helping them to save time/budget. Trip generation models conventionally take into account three types of information of an urban context: travel, land use and socio-economic characteristics. For land use side, not only the spatial location matters but also the type of land use and its intensity are important. However, there is no consistent way of discovering the real impacts of neither land use-related factors, nor the results to generalise for every geographical area.

Metropolitan areas of Iran, like those of many other developing countries, are now challenging with excessive volume of traffic. Some transport demand management (TDM) strategies based on western experiences have been proposed by local planners or governmental agencies to overcome traffic-related concerns. However, significant differences in social and economical frontiers make such policies less feasible to apply. In fact, a set of policies suggested for an urban area is unlikely to represent the interest of the population of another area, particularly in cases where there are distinctive economic and social groups (Federe, 2011). Empirical studies and evidences based on native observations can help to find out a right set of policies. Therefore, much empirical works need to be done to evaluate the real effects of land use and development plans on travel demand.

This paper is based on the assumption that households in diverse residential locations with particular socio-economic attributes have different trip rates. For this research, an integrated database of urban structure and land use features in geographic information systems (GIS), travel and socio-economic characteristics was developed. The trip-generation database was constructed by adding relevant data from several sources and developed through numerical calculations using MS Access 2010 and ESRI ArcGIS 10. The collected data included information about census tract-level travel data, socio-economic demographic characteristics and the physical attributes of urban structure and land use pattern. The integrated database was then analyzed to explore the interactions that may exist between social, land use, urban structure characteristics, and their impacts in trip generation. The primary objective was to develop conclusions about the combined impacts of land use and physical development strategies on the volume of trips generated throughout the metropolitan area. This leads to determining the relative effect of land use characteristics versus other factors on trip generation and quantify the potential influence of specific land use attributes on total travel.

Background studies

It is generally accepted that the urban form and its urban design quality do affect significantly the travel behaviors of residents, although the extent and direction of the relationship remains uncertain (Cervero & Duncan, 2006; Handy 1996). Much of the work has originated in either North America or Western Europe. The majority of these studies conclude that urban physical characteristics, ranging from regional to local in scale, have an effect on travel patterns and consequently the environmental impacts of transport such as emissions. Full reviews of the literature have been undertaken by many (Badoe & Miller, 2000; Handy,1996; Crane, 2000; Stead & Marshall, 2001; Curtis & Perkins, 2006). The majority of former studies attempt to find out the influence of urban form factors on more than one response variable. Also they tend to focus on the relative significance of the explanatory variables on travel behaviour. It is more difficult to extract the different effects of urban form variables on different travel response variables. The four response variable categories summarize the foci of most of the studies in this field are included as: trip frequency, modal split, distance travelled (vehicle kilometres travelled), and energy consumption/emissions. However, the scope of this research includes only trip generation as those produced by and attracted to a zone. Some claim that settlements with high density, mixed land use and high quality urban environment help to reduce vehicle trip generation but induce more sustainable form of travel such as walking and cycling. On the other hand, some argue that urban structure and form have marginal impacts compared to social factors and personal attitudes (Kitamura & Mokhtarian, 1997; Giuliano & Small, 1993). However, we review only those studies in which the association between urban physical form and trip generation has been investigated. The focus is more on studies experienced in developing countries.

Lin and Yang (2009) examined both direct and indirect effects of density and mixed use on trip generation in Taipei City, Taiwan. The empirical evidence showed that density is positively related to trip generation but negatively correlated with private car usage; in addition, a right mix of land uses reduces trip generation and thus indirectly increases private car use. It is suggested that intensified and mixed land use development in Taiwan needs cautious evaluation to moderate the positive impact of density on trip generation and the negative influence of density on private car use. The study by Al-Taei and Taher (2006) tried to estimate trip attraction for 20 residential traffic zones of Dohuk city, Iraq consisting of over 300 thousand residents. Attraction trips were classified into seven types and considered as dependent variables whereas some physical and social variables such as number of dwelling units, number of retail sales within CBD and employment were taken as independent variables. The results showed that although home-base (HB) work trips is related to explanatory variables with good values, but HB shopping and HB other trips have weak association with independent variables.

The study by Oyedepo and Makinde (2009) about predicting of trip generation of Ado-Ekiti Township in Nigeria, classified urban trips in three categories: home-based work purpose (HBW); home-based other purpose (HBO); non home-based purpose (NHB). The study resulted that people with higher income and higher car ownership make fewer trips than those with low income and less car availability. Also the age group of 31-50 years makes more trips in particular zones of the city. Family size was another significant factor explaining the variation in trip generation. The regression analysis was applied to discover those factors affecting school trips per household of 21 primary schools in Skudai Town, Malaysia. Some physical, social and environmental factors were examined in terms of the role they played in trip generation. Three main factors to explain the variances in trip rate at zone level were accessibility, holding capacity and cost index (land value). Accessibility was found to be the most affected factor of school trip generation

Fadare (1989), classified trips on household type and trip purpose, then compared against residential density of the area. Different residential density levels showed different effects on trip generation. In high density zones, number of employed adults and household size variables were found significant to explain the variances in trip generation level. In medium density zones, the corresponding variables were household size, number of school students, education status and age. In low density zones, education level, income, and number of vehicles were the explaining significant variables of trip generation. Boarnet and Crane (2001) tried to estimate tip generation with two-stage procedure for the Portland, Oregon. They first, calculated trip price (cost) based on several factors including land use. At the next stage, predicted price was used as an explanatory variable to predict trip generation. In other words, the effect of land use on non-wok trip generation was observed through influence on trip prices. However, since no land use variable was employed in trip generation model, planning policy implication would be limited.

From the literature it is clear that urban physical form can be an influential factor in trip making in some ways. The location of the residence relative to the town centre along with a range of urban form factors at a more detailed level, all of which influences the residents' need for transport: accessibility to workplaces, shopping opportunities, leisure activities and schools. However, results vary according to the geography and socio-economic status.

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Research methodology

Trip estimation methods

In this study, a *trip* is defined as 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). Trip generation is measured by the trip generation rate, defined by the daily sum of trip production and trip attraction in a TAZ divided by the total floor area of a TAZ in unit of trip numbers/100 square meters. Generally, there are three approaches to estimate trip production: a) multiple regression analysis; b) land use and activity rate; and c) category analysis.

Multiple regressions assume the trip production as a linear function of explanatory factors (such as population, car ownership, income level and employment attributes) which are more social-based at where trips originated but more location-based at where trips ended. In this regard, trips are categorized into groups: if either origin or destination of a trip is the home of the trip maker then such trips are called home based trips and the rest of the trips are called non-home based trips. However, trip production is defined as all the trips of home based or as the origin of the non home based trips. Therefore, it can be said that land use characteristics are more relevant to non-home based trips.

The second approach assumes travel as an activity produced by land uses. Typically, a trip production rate is used for each land use category to calculate how many trips a site of the given category will generate. Defining a trip production rate for each land use category is based on the nature of land use and its observed travel activity. In this regard, using of the Institute of Transportation Engineers (ITE, 2001) rates for trip production is common in many cases. A similar approach is provided by British TRICS database providing information on different trip generation and attraction rates for the full range of development types.

In category analysis, trip ends are classified by characteristics of the zone as unit of analysis. In fact, trip generation as dependent variable is cross-tabulated against limited independent variables, such as trips per household versus income or car ownership. The variables are divided into distinct classes. This method allows the modeler to get a good understanding of the role each variable plays on trip generation. However, detailed data are required to construct and predict trip generation.

Trip attraction model is more associated with non-residential land uses (FHA, 1975). Development of trip rates is based on trip-maker's characteristics as well as trip purpose. Then trips for the entire area are accumulated for different cells of the matrix. Trip attraction model is developed using estimates of explanatory variables such as household income and car ownership. For trip distribution purposes, the area-wide production and attraction estimates should be equal. In fact, the area-wide summation of attractions should be the same as the summation of productions for each home-based purpose as estimated by the trip generation models (FHA, 1975). Since they are estimated separately by different models with different variables, a balancing factor is applied.

For trip generation prediction in a metropolitan scale area, regression method is recommended because it has advantages as a model building procedure and makes better use of sample data. Although a certain amount of categorization of household types is required, however, further development will be restricted if the trend towards minimum sample sizes of about 1000 households is continued (Douglas, 1973). For this reason, this study used regression analysis for developing trip generation model because of more flexibility in considering a wide range of factors, capability for graphical and normative interpretation as well as possibility of error estimation. It enables us to measure the importance of each factor in trip generation through sensitivity analysis. However, precautions are required to avoid potential co-linearity among independent variables. On the other hand, the regression method is criticized due to its black box nature. Also by using zonal averages, important socioeconomic variations within the zone may be obscured or may yield spurious results. A simplified trip-oriented approach is unable to examine complex behaviour of travellers, thus a wider framework of space/time is required. In this way, utility-based and activity-based theories are suggested (Maat & Stead 2005).

Data

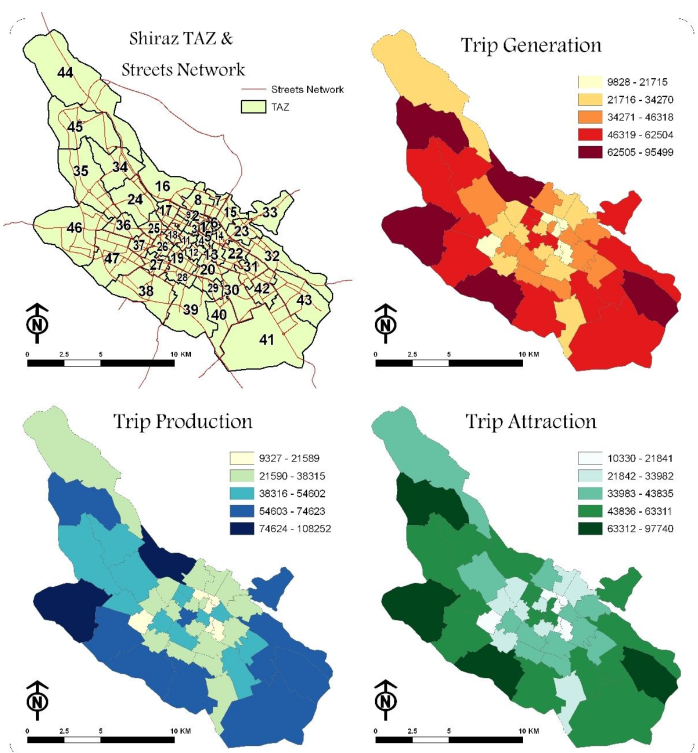
Metropolitan Shiraz is the case study of this study. Shiraz is the fifth largest city of Iran in terms of population and is located in the south of Iran and the northwest of *Fars* Province. The population of Shiraz city is over 1.4 million people with an annual growth of 1.3. The newest population data of Shiraz belongs to 2006 Census (ICB, 2006). The metropolitan consists of 47 TAZ and the average population of a zone is 25187 people. Trip diary data was collected by Shiraz University for around 5 percent of population. The average numbers of trip production, attraction, and generation of a zone are 43632, 43361 and 43496 trips respectively. Fig.1 shows the distribution of zones throughout the metropolitan area as well as trip generation statistics for 2006.

Analysis and findings

The aim of the analysis is to quantifying the number of trips that each zone will produce or attract. As noted earlier, 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. The social and economic characteristics of trip-makers such as age, employment status, education and income level can influence the number of trips that are generated by a zone. Furthermore, physical-form attributes including density, land use distribution, and network layout and properties are important.

Therefore, three types of variables applied to predict trip generation of a zone: a) socio-economic characteristics included education level, age groups, employment, number of households, population, immigration and number of students; b) urban physical characteristics included average floor area ratio, population density, distance from CBD, share of non-residential land uses, share of residential land uses; and c) public transport variables. Among a long list of variables, some were selected based on an initial correlation analysis. The descriptive statistics of those variables which applied in statistical analyses are provided in Table 1.

Fig.1. Case study area and spatial distribution of travel activities



The concern with collinearity is an important issue particularly in regard to the contribution of multiple dimensions of urban form. Cervero (2002) echoes the concern of collinearity by questioning whether urban design factors are not correlated with density. In a study of transit-supportive designs across a number of cities in the United States, he concluded that “micro-design elements are too micro to exert any fundamental influence on travel behaviour; more macro factors like density and the comparative cost of transit versus automobile travel are the principal determinants of commuting choices” (Cervero, 2002). Krizek (2003) argues that urban form attributes such as compact development, mixed land uses, and quality environments can be created together. Such features represent a bundle of characteristics usually found together. This makes it difficult to separate the independent impacts of one characteristic. Extreme collinearity between many of the variables prevents it from making statistical sense.
Therefore, independent measures may be useful to better understand travel behaviour and guide land use policy. Therefore, the next important step is to determine whether there is evidence of interaction in the data.

Table 1. Descriptive statistics

Variable name	Description	Min.	Max.	Mean	Std. Dev.
TG	Trip generated (intra-zones)	9828.32	95499.34	43496.40	18758.21
A25_64	Sum of aged between 25 and 64	1170.00	45881.00	15628.30	11055.21
SS	Sum of students	472.00	14566.00	5038.85	3673.38
SE	Sum of employees	523.00	21408.00	7329.94	5186.93
SBNS	Sum of those born out of Shiraz	6.56	198.66	56.47	50.81
SNFD	Sum of all accessibility to public transport from all parcels (bus line*services/ area)	0.72	19.23	6.32	3.51
ADS	Average of parcel distance to nearest bus stop (m)	1.83	301.72	591.62	757.25
NRA	Non Residential Area (sqm)	95320.01	5305509.62	1151348.16	1098507.37
SFA	Sum of floor area	124502.49	1174116.25	478731.99	249548.20
LD	Linear distance to CBD (km)	0.00	11116.85	4048.27	2662.57
LDS	Linear Distance to CBD squared (sqkm)	0.00	123584435.84	23326934.68	28482564.00
LLD	Logarithm (natural) of linear distance to CBD	6.36	9.32	8.11	0.70
PV	Property value (m toman)	5.45E+15	1.06E+18	1.40E+17	2.09E+17
Valid N		47			

To avoid potential co-linearity existed among these variables, it is decided to conduct a PCA analysis to discover those variables which played main role in explaining variances. Therefore PCA analysis was used to combine correlated variables into a single group. In fact, this method helps us to have similar variables combined into single continuous variables that maintain or that eliminate the co-linearity problems without

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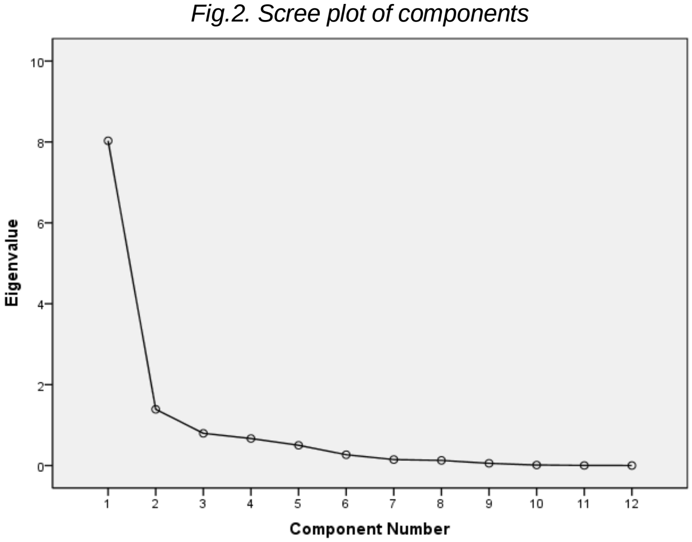
sacrificing explanatory power. The aim of factor analysis is to reduce the number of *p* variables to a smaller set of parsimonious $k<p$ variables with the objective of describing the covariance among many variables in terms of a few unobservable factors (Morrison, 1990). The result of PCA showed that five groups of variables can be considered as the best variables explaining the variances in dependent variable (94.87 percent in total) (Table 2). This is shown as a scree plot on Fig.2.

Table 2. Total variance explained by explanatory variables

Component	Initial eigenvalues			Extraction sums of squared loadings		
	Total	Percent of variance	Cumulative percent	Total	Percent of variance	Cumulative percent
1	8.028	66.903	66.903	8.028	66.903	66.903
2	1.391	11.591	78.493	1.391	11.591	78.493
3	.797	6.642	85.135	.797	6.642	85.135
4	.668	5.567	90.702	.668	5.567	90.702
5	.501	4.172	94.874	.501	4.172	94.874
6	.267	2.226	97.100			
7	.147	1.229	98.329			
8	.127	1.062	99.391			
9	.056	.466	99.857			
10	.013	.111	99.968			
11	.002	.019	99.988			
12	.001	.012	100.000			

Fig.2. Scree plot of components



According to the Component Matrix (Table 3), five principal components can be categorized as: Component 1: age group between 25 and 65; student; employee; non-Shiraz born; Component 2: distance to CBD; Component 3: public bus network frequency; Component 4: property value; and Component 5: distance to public bus stop. These five groups can be considered as proxies of five characteristics of the zones: socio-demographics; suburbanization; public transport service quality; household economy; and accessibility to public transport respectively.

After the identification of important variables from factor analysis, these were then run into the SPSS software for multiple linear regression process to explore the role of these characteristics in trip generation. A summary of multiple linear regression is provided below (Table 4). The model is linear as ANOVA test showed ($F=19.197$, $p<0.000$). The adjusted R-square value is 0.652 showing an appropriate goodness of fit. However, only four groups of variables were found to be statistically significant ($p<0.10$).

The areas with higher share of young people (aged between 25 and 65); students and employed people as well as migrated people are likely to have higher share of trip generation. On the other hand, areas located farther from CBD have lower shares of trip generation. According to current evidences, suburbs of Shiraz are occupied by low-income and generally mobility disadvantaged groups thus lower level of trip generation is expected. In fact, a large part of low-income people who cannot afford a private transport and usually live in suburban and remote areas at the fringe of metropolitan regions are distant to the variety of places they need to access (Soltani *et al*., 2011). This result is contradictory with what has been found by Miller and Soberman (2003) in Canada. According to their study, total trips increased at a greater rate than population in suburban zones. This may partially reflect employment-related trip generation effects in these areas, but it also is an indication that transit services in these zones tended to not follow travel needs.

Table 3. Component Matrix

Variable	Component				
	1	2	3	4	5
A25_64	.961	-.161			-.160
SS	.960	-.154			-.177
SE	.959	-.165			-.111
SBNS	.858	-.420	-.123		.113
SNFD	.542	-.210	.757		.170
ADS	.695	.131	-.225	.134	.491
NRA	.633	-.181	-.165	.108	
SFA	.534	-.434			-.104
LD	.658	.440		-.244	
LDS	.593	.526		-.149	
LLD	.629	.419		-.355	
PV	.555	.133	.222	.454	-.288

The zones with higher mean value of properties had greater level of trip generation. This shows the direct link between economy status and travel making. This finding is similar to what have been found in some previous studies, e.g. Popoola-and-Faborode (2009). Finally, the farther distance to public transport stops, the lower is the likelihood of generating a trip. In fact, the provision of public transit services induces more travel.

Table 4. Result of regression

	B	Beta	T	Sig.
Constant	43366.791		25.119	.000
Component *1*	13951.839	.736	7.993	.000
Component *2*	-3693.414	-.195	-2.116	.040
Component *4*	4074.278	.215	2.334	.025
Component *5*	-3011.393	-.159	-1.725	.092

Regression analysis confirmed that socio-economic status is the most significant factor affecting trip generation level. In a similar Iranian study, it was found that household-income and the numbers of full-time workers were the most important factors affecting trip-generation (Arabani & Amani 2007). On the other hand, since only intra-zone trips were examined here, some important urban physical factors such as land use mix and street layout were found not to be significant affecting trip generation. Rather, they probably influence trips generated within the zones as well as local trips (Handy, 1996). Banister (2007) argues that improved local accessibility can reduce the need to travel, though it may also increase the tendency to travel, so that the overall effect is more travel. On contrast, Ewing *et al.* (1996) reported no significant relationship between land use and trip generation.

Conclusions and further investigation

This study reveals that socio-economic characteristics are most positive determinants of intra-zone trip generation. On contrast, suburbanization (distance from CBD) and distance from public transport facilities are negatively associated with trip generation level. However, other physical factors such as land use mix and network connectivity were found not important in affecting intra-zone trip generation, probably influencing inter-zone trip generation instead. While exclusionary zoning and market forces have tended to segregate activities and lengthen trips, bringing origin and destinations closer together is associated to decrease daily travel activities. Better urban form would locate workplaces and activities linked as trip productions and attractions are as close together as possible.

This research is a primary step in Iranian context while the majority of current literature on urban form-trip generation come from Western world thus their findings are hardly generalizable to a developing country context. In fact, given the social and geographical differences, every urban development pattern has its own function to make more mobility choices and opportunities. Future research should consider more exploratory approaches for developing a deeper understanding of the behavior that underlies the observed link between urban form and travel patterns. In addition, such kind of information should be gathered from the characteristics of originations and destinations of daily commuting. Similarly, data on the origin and destination of midday travel, trip chaining, or other related topics were not included, while the generation of those trips made outside of the origin zones are important as well. Also, the current analysis can be developed to cover different types of urban trips categorized either on travel purpose or mode of travel. A more disaggregated approach to study of trip generation could discover several other aspects of travel activities. In fact, an expanded model might consider trips for different purposes simultaneously. Furthermore, the variables discussed here, can interact in quite complex ways in trip generation; therefore, applying more advanced statistical methods could discover the effect of the interactions between the variables. Finally, the estimations are based on 2006 data, thus, using a more recent data may produce more reliable estimates. This is an important point needs more attention especially with socio-economic changes experienced by the society within last five -years.

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References

1. Al-Taei AK and Taher MA (2006) Trip Attraction Development Statistical Model in Dohuk City Residential Area, Al-Rafidain Engineering, 14(2),12-23.
2. Arabani M and Amani B (2007) Evaluating the parameters affecting urban trip-generation. *Iranian J. Sci. & Technol. Transact. B, Engg*. 31(B5), 547-560.
3. Banister D (2007) Land use, planning and infrastructure issues in transport. Commissioned paper for the Shadow Committee on Climate Change, Dec 2007 Transport Studies Unit Oxford University Centre for the Environment.
4. Badoe D and Miller E (2000) Transportation-land use interaction: empirical findings in North America, and their implications for modeling. *Transport. Res*. Part D5 (4), 235-263.
5. Ben-Edigbe J and Rahman R (2010) Multivariate school travel demand regression based on trip attractions. *World Acad. Sci. Engg. Technol.* 66,1695-1699. www.waset.org/journals/waset/v66/v66-263.pdf.
6. Boarnet M and Crane R (2001) Travel by design: The influence of urban form on travel. Oxford Univ.
7. Cervero R (2002) Built environments and mode choice: toward a normative framework. *Transport. Res.* Part D (7), 265-284.

8. Cervero R and Duncan M (2006) Which reduces vehicle travel more: jobs-housing Balance or retail-housing mixing? *J. Am. Planning Asso*. 72 (4), 475-488.
9. Crane R (2000) The influence of urban form on travel: an interpretative review. *J. Plan. Edu. & Res*. 15 (1), 3-23.
10. Curtis C and Perkins T (2006) Travel behavior: a review of recent literature. In: Working Paper no 3., Department of Urban and Regional Planning, Curtin University, Perth. http://urbanet.curtin.edu.au/local/pdf/ ARC_TOD_ Working_Paper_3.pdf.
11. Douglas AA (1973) Home-based trip end models-a comparison between category analysis and regression analysis procedures. *Transport*. 14, 253-270.
12. Ewing R Deanna M and Li SC (1996) Land use impacts on trip generation rates. *Transport. Res. Record*. 1518, 1-6.
13. Fadare SO (2010) Urban form and households' travel behavior: implications for Nigeria. Oauife Univ. Press, www.oauife.edu.ng/inaugural/fadare.pdf
14. Fadare SO (1989) Analysis of factors affecting household trip generation in residential areas, Ibadan. *Ife Res. Publ. in Geography*. 5, 34-48.
15. FHA (1975) Trip generation analysis. U.S. Government Printing Office, Washington D.C. http://www.otdmug.org/ media/ 3445/chapter4.pdf.
16. Giuliano G and KA Small (1993) Is the journey to work explained by urban structure? *Urban Studies.* 30, 1485-1500.
17. Greenwald, Michael J (2006) The relationship between land use and trip internalization behaviors: Evidence and Implications. In: TRB 2006 Annual Meeting, CD-ROM.
18. Handy S (1996) Understanding the link between urban form and non work travel behavior. J*. Planning Edu. Res*. 15, 183-198.
19. ICB (Iran Census Bureau) (2006). Center of National Statistics. Databank of Fars Province.
20. ITE (2001). The Institute of Transportation Engineers' Trip Generation Handbook. http://www.ite.org/tripgen/ Trip_Generation_Data_Form.pdf.
21. Kitamura R and Mokhtarian PL (1997) A micro-analysis of land use and travel in five neighbourhoods in the San Francisco Bay Area. *Transport*. 24, 125-158.
22. Krizek KJ (2003) Operationalizing neighbourhood accessibility for land use-travel behaviour research and regional modeling. Ph.D. Thesis, University of Minneapolis, Minneapolis.
23. Lin JJ and Yang AT (2009) Structural analysis of how urban form impacts travel demand: Evidence from Taipei. *J. Urban Studies*. 46,1951-1958.
24. Maat K, Wee B and Stead D (2005) Land use and travel behaviour: expected effects from the perspective of utility theory and activity-based theories. *Environ. & Planning B: Planning & Design*. 32(1), 33-46. www.envplan.com/abstract.cgi?id=b31106.
25. Miller E and Soberman R (2003) Travel demand and urban form. In: Smart growth issue papers. www.rethinkgreen.ca.
26. Morrison DF (1990) Multivariate statistical methods. McGraw-Hill, NY.
27. Oyedepo OJ and Makinde OO (2009) Regression model of household trip generation of Ado-Ekiti township in Nigeria. *Eur. J. Sci. Res*. 28 (1),132-140. http://www.eurojournals.com/ejsr.htm.
28. Popoola KO and Faborode TG (2009) Status on household all purpose travel pattern of men and women in Ibadan. Dept. of Urban & Regional Planning, Obafemi Awolowo Univ. www.nai.uu.se/ecas-4/panels/61/Popoola-and-Faborode-Full-paper.pdf.
29. Soltani A Celik HM and Esmaeili Y (2011) An investigation of the social equity of public bus service distribution: a case study of Shiraz metropolitan area. *Cities J*. (communicated).
30. Stead D and Marshall S (2001) The relationships between urban form and travel patterns. An international review and evaluation. *EJTIR*. 1(2), 113-141.
31. TRB (Transport Research Board) (2011). Trip generation definition. Washington, D.C. http://www.TRB.org.
32. TRICS (2011). Trip generation and land use categories. http://www.trics.org/tricssystem.html.
33. Williams K (2000) Does intensifying cities make them more sustainable? In: Achieving sustainable urban form. Williams K, Burton E & Jenks M (Eds.), E & F Spon, London.