Trip Generation Analysis in a Developing Country Context

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A household trip rate analysis that uses the cross-classification method and applies in a developing country context is presented. The importance of choosing, defining, and classifying variables and using an appropriate analytic technique related to the socioeconomic values and travel behavior of residents in developing countries is stressed. Trip rates, expressed as the average number of person-trips per household classified by purpose of trip and mode of travel, were established for four variables of the household (income, size, car ownership, and number of employed persons). Household income and size were each classified into six groups, and car ownership and number of employed persons were classified into four and three groups, respectively. The standard cross-classification method was used to determine which household characteristics, given limited data, most influence trip making. The results indicate that large household sizes reflecting the extended family system in developing countries significantly affect trip making. Together with car ownership and the number of employed persons in the household, household size as a variable performs significantly better than household income for work, school, and shopping trips, which make up more than 60 percent of total household trips.

The growing volume and complexity of urban travel in developing countries should be a major concern to transportation planners, service sponsors in urban areas, and policy makers. One component that seems to have been neglected or taken for granted in the planning of cities in the developing world is travel demand analysis. There is no systematic analysis of established relationships between various forms of land use and attitudes of trip makers to guide planning of major developments and activity centers. This deficiency limits the effectiveness of transportation policies and actions in meeting the needs of expanding urban populations in the developing world.

In contrast, travel demand analysis has been a major component of transportation planning in the developed world for many decades (*1*,*2*). In the 1950s and 1960s, most transportation planning studies focused on developing person-trip production models using zonal variables such as residential density, type of dwelling unit, and number of employed residents. The primary method of analysis of these models was linear regression (*3*,*4*). However, in the 1970s and 1980s a more disaggregate trip generation model based on household variables such as income, car ownership, and family size was developed. Regression analysis was (and is) used in most household trip generation studies. In early 1970, in response to the need for greater disaggregation in trip rate analysis, an alternative, the cross-classification method (also referred to as category analysis), was developed (*5*). This method uses categorized variables, such as household size, car ownership, and income, as integer values to describe individual households. For instance, integer values of household size could be 1 to 2 persons per household, 3 to 4 persons per household, 5 to 6 persons per household, and more than 6 persons per household. The definition and classification schemes must be based on the nature of residential living arrangements and the concepts of family and household. These concepts vary in meaning and scope from one place to another. Analysis of variance (ANOVA) is sometimes used to determine which groups or variables of households are better classification schemes for modeling (*6*). Recently, multiple classification analysis (MCA) has been used to determine interaction effects, comparative analysis of alternative models, and cell rates for small samples (*7*). The desire for further disaggregation of trip generation analysis has led to the development of the person category models as an alternative to the household models (*8*). Another variation of the disaggregated household models is the household structure concept (*9*). Although the person level of data aggregation has been found to be useful for travel demand analysis based on demographic factors, it does not incorporate household structure and interaction effects or household money and budget costs into the analysis. These models, however, use the cross-classification and the regression methods to analyze the data.

The primary advantages of the cross-classification method over the regression method are as follows: (*a*) it does not require a linear or monotonic relationship between the variables and (*b*) it permits a more comprehensive analysis of trip making by showing the relationships among different classes of households. It may also be a better method when the data are insufficient because of large standard errors and uncertainty in model parameters associated with small sample sizes. On the other hand, the regression method allows results of trip generation models to be used for prediction beyond the calibrated data.

Because trip generation studies have been well documented in the developed countries, most of the established practices, such as the choice of an analytic technique and the selection and specification of variables, are based on travel behavior and demographic characteristics of residents in developed countries. This paper examines these issues in the light of conditions in developing countries. The results of a trip generation study carried out in Kumasi, Ghana, are presented. Kumasi, the second-largest city in Ghana, is a rapidly expanding urban center (population 700,000) with a growing demand for travel.

An earlier version of this study used linear regression analysis (*10*). The cross-classification method is used here because

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it deals with the nonlinearities observed between some of the variables and the average number of person-trips per household. It also allows more detailed analysis of the variables.

Few studies have been made of travel demand in Ghana, as is true of other parts of the developing world. Some studies, however, have been made of traffic generation of commercial areas, hospitals, and industrial establishments (*11–13*). One study of trip generation that deserves mention is an analysis of urban travel characteristics in Accra (*14*). Although the study recognizes the importance of the household unit in the generation process, it confuses residential zonal treatment with household treatment in the selection and measurement of variables. The study also attempts to derive conventional trip generation models for residential zones by making the convenient simplifying assumption that all trips by households in a residential zone are home-based and single-destination trips. The study reported here seeks to correct the shortcomings of those traditional assumptions of urban travel analysis and to eliminate the error that might be introduced into forecasts of future urban travel in Kumasi.

Data collection procedures, selection of variables, and definition of a classification scheme are discussed. Four household variables—income, size, car ownership, and the number of members employed—are analyzed. Household income and household size are each grouped into six categories, and car ownership and the number of employed persons are grouped into four and three categories, respectively. Trip rates are established for specific household categories in terms of the average number of person-trips per household classified by purpose and mode of travel. The standard cross-classification method is employed to determine which variables and categories have the strongest relationships to trip making. To explore further variations in the data, a one-way ANOVA was performed. This allowed two-way tabulations of specific variables to be included and discussed.

DATA COLLECTION

Field Survey

Data were obtained largely through a home interview survey of travel patterns of household residents in Kumasi. The survey was conducted during April and May 1979. The data were updated in 1983. The survey usually started around 4:30 p.m. and ended around 7:30 p.m. each weekday.

Using the Kumasi City Council's 1978 property rating, 6 residential zones out of a total of 50 were selected for the home interview survey. The selected zones consisted of two high-income residential zones (Nhyiaeso and the U.S.T. Ridge), two medium-income zones (Kwadaso Estate and Menhyia Extension), and two low-income zones (Old Tafo and Asawasi). To account for the influence of differences in distance from the central business district (CBD) on trip frequency, a zone closer to the CBD and another further away were selected for each group. Figure 1 shows the six selected zones in relation to the CBD of Kumasi.

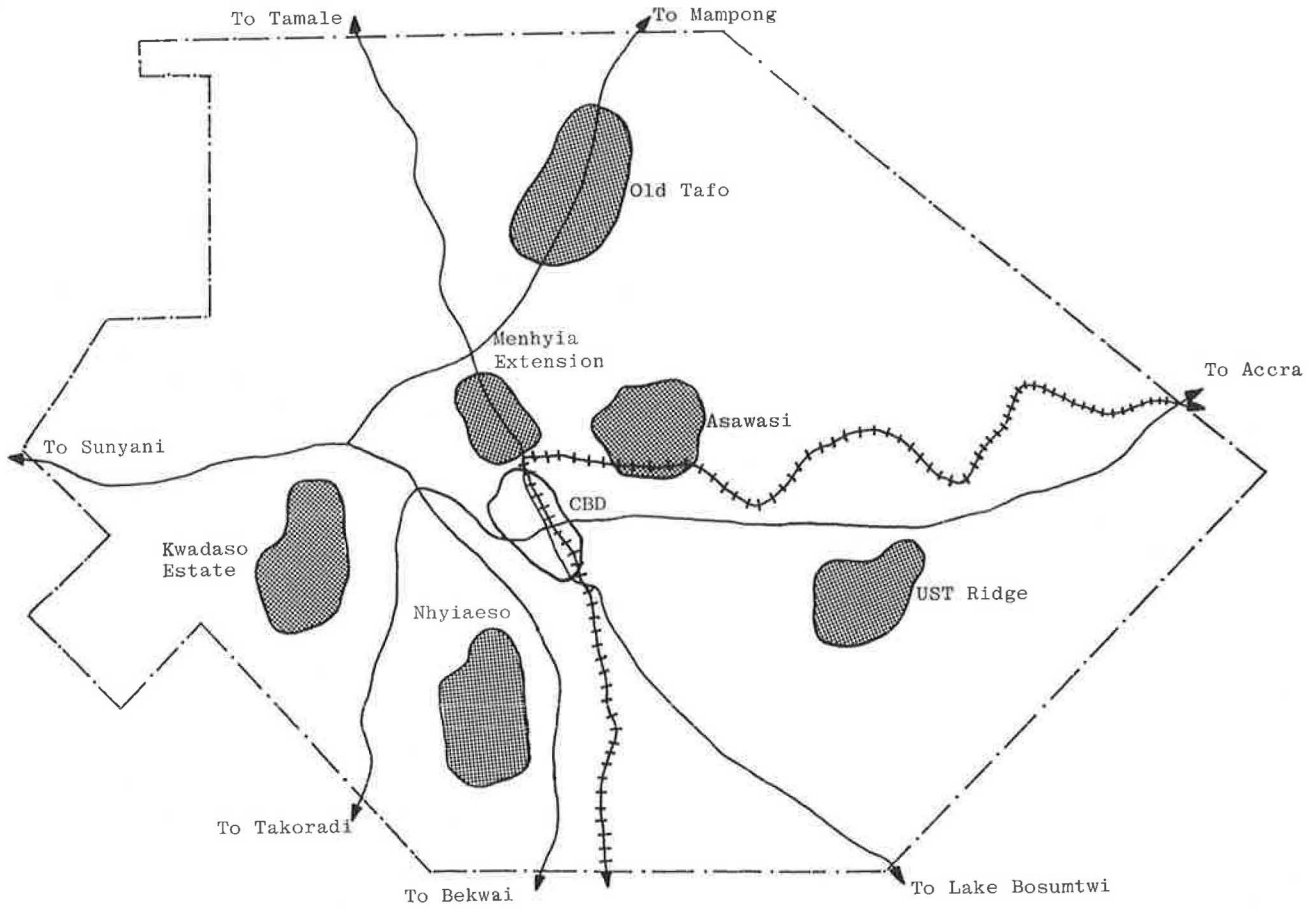

FIGURE 1 Kumasi City Council area showing six selected zones in relation to the CBD.

The selected zones are purely residential areas. As a result, trip attraction rates from other areas to the selected zones were negligible. Most trips are CBD-oriented because all major commercial work and other trip-generating activities are located in the CBD.

Households in the six residential zones were selected for interviews on the basis of the stage sampling technique and minimum standards recommended by Bruton (*15*). Stage sampling is a technique that allows samples to be chosen randomly from a stratified population. The minimum standards recommended by Bruton were modified to account for differences in residential family structure and household densities between Great Britain and Ghana. For instance, a minimum sample of 1:70 or a recommended sample of 1:20 is required for a population between 500,000 and 1,000,000. However, to achieve a greater level of accuracy, a sample of 1:20 was applied to residential areas with high household densities (such as Old Tafo) and a larger sample of 1:10 was applied to zones with smaller household densities and dwelling units (such as Nhyiaeso). In all, 673 households were interviewed from a sample of 188 houses.

In the Ghanaian residential system a number of individual households who may or may not belong to the same family live in the same house. Of the households interviewed, the average household size ranged from 1.31 in U.S.T. Ridge to 5.10 in Old Tafo. The average household size of the total sample was 3.19. However, 72 percent (484) of all households had four or more persons.

Variables and Categories

Trip generation analysis of residential land use employs a number of independent variables that are known to influence trip making, including family income, car ownership, household size, type of dwelling unit, household composition, land use factors, accessibility, and level of public transportation service (*16*). The intensity, character, and location of land use, measured by dwelling units per acre, land area of nonresidential uses, and distance from the CBD, are important in explaining some of the variations in trip making. Similarly, the level of accessibility and transportation service, characterized by route structure, spacing and coverage, congestion levels, and level-of-service quality criteria, are useful explanatory variables.

In applying these variables to trip generation analysis in developing countries, differences between developed and developing countries need to be considered. For example, compared with developing countries, developed countries have more working-parent households and nuclear family living arrangements, greater use of the telephone system, and other communication devices such as fax machines. These characteristics can reduce personalized trips and lessen concentration and centralization of commercial activities, producing multiple trip purpose patterns and more convenient use of the public transportation system for urban trips. Selection, definition, and classification of variables in this study took into account these differences.

Four independent variables were selected on the basis of two factors: (*a*) their expected influence on trip production and attraction rates in developing countries and (*b*) their measurable characteristics as household variables. The selected independent variables were

1. Household income,
2. Household size,
3. Number of cars owned per household, and
4. Number of employed persons per household.

Each variable, together with its expected effects on trip production, is described briefly.

Household income is defined as the average annual disposable income of the head of the household, measured in cedis (₵). In Ghana and in other parts of the developing world where a strong extended family system is practiced, the income of the head of the household is recognized as the only legitimate source of support for the entire family. This contrasts with the nuclear family system in the developed countries where the income of other family members can be counted as part of the household income. In general, income represents the ability of a family to pay for its travel. Thus, trip making is expected to increase as the income of the household increases because the money available to satisfy previously unsatisfied travel demands increases.

Household income was grouped into six categories: low (₵0 to ₵1,200 and ₵1,201 to ₵2,400), medium (₵2,401 to ₵3,600 and ₵3,601 to ₵4,800), and high (₵4,801 to ₵6,000 and more than ₵6,000). The categories represent the socioeconomic status of the household at the time of the survey. For an equivalent household today, each range should be multiplied by six to account for inflation and devaluation of the Ghanaian cedi.

Household size is defined as the number of persons in the household. The number of persons counted in a household includes not only the members of the nuclear family (sons, daughters, etc.) but also other family members (nephews, cousins, nieces, etc.) who reside and eat with the nuclear family members from the same income. Even within the nuclear family structure there could be sons and daughters from different wives of the male head of household because of the polygamous marriage system practiced in some parts of developing countries. This situation usually makes the size of households in developing countries higher than in developed countries that do not practice the extended family system. Larger household size is expected to cause increases in trip making because, with more people in the household, more trips are likely to be made, although the trip purposes may differ.

Household size was grouped into six categories: 1 to 2, 3 to 4, 5 to 6, 7 to 8, 9 to 10, and more than 10. This grouping allowed all types of household sizes in the extended family culture to be covered in the analysis.

Car ownership is measured by the number of automobiles, vans, and lightweight trucks owned by the household and available for use by members. Exclusive use of an automobile by the owner or immediate family members is discouraged by the living arrangements and the extended family system. The ownership of a car, therefore, offers the entire household an opportunity to satisfy its travel needs, especially for motorized trips. The problem is that there is usually only one driver (the owner) for the entire household. Generally, a car-owning household is expected to generate more trips than a non-car-owning household.

The number of cars owned was classified into four groups: zero, one, two, and three or more. This grouping reflects the

disparity in affluence in developing countries, which is represented in part by the number of cars owned.

The number of employed persons in the household represents the number of full-time or part-time workers living in the household. Usually, in households of more than one employed person, the workers are self-employed artisans or traders who do not earn steady incomes. Their trip-making behavior is influenced by the nature of their work, and often it is difficult to document such trips. Clearly, the number of workers will be in direct proportion to and is causative of the number of household work trips.

The number of employed persons in the household was grouped into three categories: one, two, and three or more workers.

Definitions

Trip rate analysis classified by purpose and mode of travel was performed for each household variable (i) and category (j) using the following formula:

$$t_{ij}^{p/m} = T_{ij}^{p/m}/H_{ij}$$

where

$t_{ij}^{p/m}$ = trip rate for purpose p or mode of travel m for category j of variable i,
$T_{ij}^{p/m}$ = observed trips for purpose p or mode m for category j of variable i, and
H_{ij} = observed number of households for category j of variable i.

To compute trip rates, households in the survey were grouped into the individual cells represented by the observed trips by purpose or modal group. The trip rate was then the total trips in a cell by purpose or mode of travel divided by the number of households in that cell. The purposes of trip makers were grouped into six categories: work, school, shopping, sports and entertainment, social, and other. Social trips were trips made to visit relatives or to take part in a funeral service. The "other" category covers trips made to transfer from one mode to another, to seek medical attention, or for a business-related purpose such as a trip to the bank. The trip-purpose classification applies to all trips, home-based and non-home-based.

Modes for making the trips were classified into six groups: car, trotro, bus, taxi, motorcycle, and walking. "Trotro" is the name of the paratransit or jitney system in Ghana. Vehicles used as trotros are usually 12- to 20-passenger minibuses or large bedford trucks (sometimes with wooden benches) operating along a fixed or semifixed route by private entrepreneurs (*17*). Walking was included as a mode because in small cities of the developing world many trips are made on foot—residences are often near activity centers and there may be a lack of adequate, efficient, and affordable intracity transportation services.

Two other independent variables were used in the study design and data collection: the distance of the household from the CBD and the average ratable value of residential property. The dependent variable used in the analysis was the average number of trips per household per day.

TRIP RATE ANALYSIS

Trip rates were established for the household variables and were classified according to the purpose of the trip, mode of travel, and total trips reported by each household. This method of classification incorporates different trip distribution and modal split characteristics in the trip generation analysis.

Trip Purpose

The influence of household size, household income, and the number of employed persons per household on trip purpose is shown in Table 1 and Figures 2–4.

It can be observed from Figure 2 and Table 1 that, in general, the household trip rate increased steadily as the size of the household increased. This trend was more pronounced in the work, school, and shopping trips. For example, households of one to two persons made 0.85 and 0.66 work and school trips, respectively. The corresponding trip rates for households of 9 to 10 persons were 2.30 and 1.25 trips. Typically, larger households had greater proportions of children; hence, the practical concavity of the school purpose trip curve in Figure 2. Similarly, sports and entertainment trips tended to increase with household size. In contrast to the general trend, trip rates for social purposes increased with household size only up to seven- to eight-person households and then flattened out. This suggests that an increase in household size beyond the average of seven to eight persons has no significant influence on the rate of social trips made. The reason for this is that trips to satisfy social needs are normally made by adults; because larger households contain higher proportions of children, social trips are not largely represented in such households.

The influence of household income on trip purpose rates as shown in Figure 3 and Table 1 was similar to that of household size except that the variation of increase in trip rates was smaller in higher-income households as compared with that in larger household units. Whereas households with incomes below ₵3,601 enjoyed higher trip rates for all purposes, those with incomes above ₵3,601 had proportionately smaller increases in trip rates. It is interesting to note that shopping, social, and school trips tended to be independent of income for households with income ranges of ₵4,801 to ₵6,000 and more than ₵6,000. There was also no significant influence on work trips. Sports and entertainment trips and those classified as "other" were particularly influenced by household income because there was a steady increase in trip rates for all household income categories. This is because shopping, school, and work trips are basic trips that each household must undertake irrespective of its financial circumstances. However, this is not true for entertainment and sports, social, and "other" trips.

The level of household employment had a similar effect on trip rates (see Table 1 and Figure 4). In general, all trips except shopping trips varied with the number of employed persons in the household. Shopping trip rates decreased from 3.12 for households with two employed persons to 3.07 for households with three or more employed persons. Despite this slight deviation, a significant number of trips were made to satisfy shopping and entertainment needs. The total for

TABLE 1 HOUSEHOLD TRIP RATES BY PURPOSE OF TRAVEL

Household Category		Work	School	Shopping	Social	Sport and Entertainment	Other
Household Size	1 - 2	0.85	0.66	0.69	0.51	0.28	0.14
	3 - 4	0.81	0.78	0.75	0.62	0.42	0.18
	5 - 6	1.73	0.92	0.98	0.78	0.56	0.20
	7 - 8	1.88	0.99	1.17	1.05	0.73	0.22
	9 - 10	2.30	1.25	1.42	1.06	1.01	0.23
	11 +	2.36	1.87	1.69	1.06	1.24	0.36
Household Income (in Cedis)	0 - 1,200	0.79	0.64	0.46	0.34	0.62	0.19
	1,201 - 2,400	0.82	0.80	0.76	0.49	0.78	0.24
	2,401 - 3,600	1.64	0.94	1.32	0.71	0.82	0.30
	3,601 - 4,800	2.10	1.09	1.38	0.67	0.85	0.34
	4,801 - 6,000	2.13	1.00	1.38	1.33	0.89	0.50
	6,000 +	2.16	0.98	1.39	1.31	0.93	0.72
Number Employed In Household	1	2.81	1.52	2.08	0.20	1.45	0.26
	2	3.64	1.58	3.12	0.66	2.68	0.29
	3 +	3.91	2.31	3.07	0.75	2.93	0.50

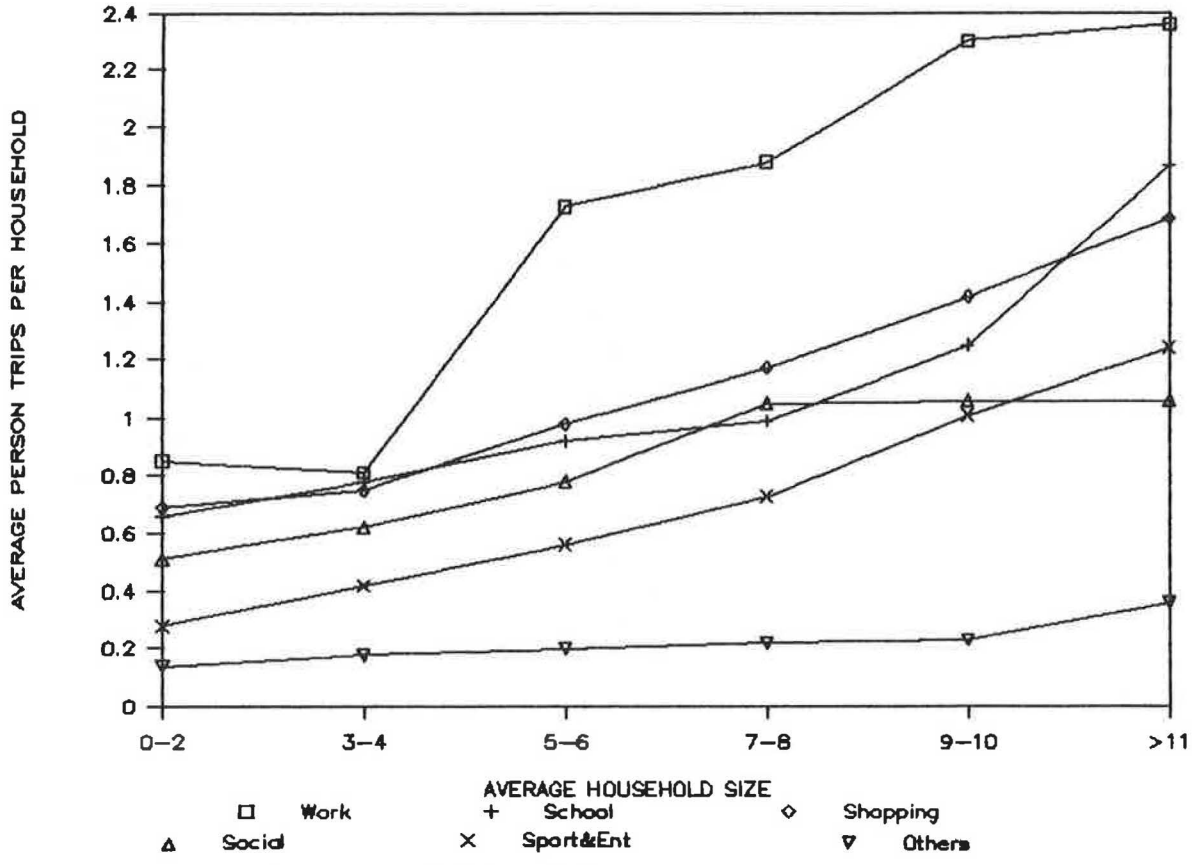

FIGURE 2 Household trip rate by household size and trip purpose.

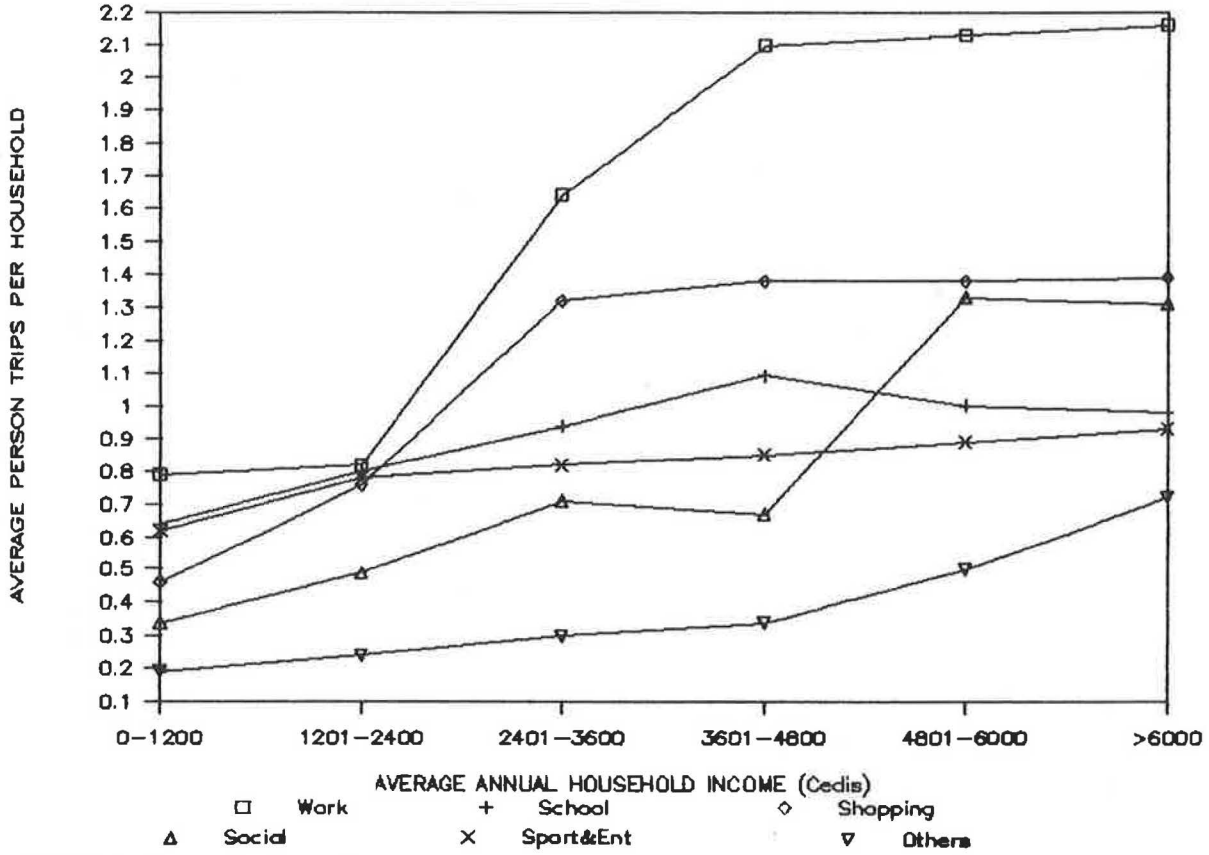

FIGURE 3 Household trip rate by household income and trip purpose.

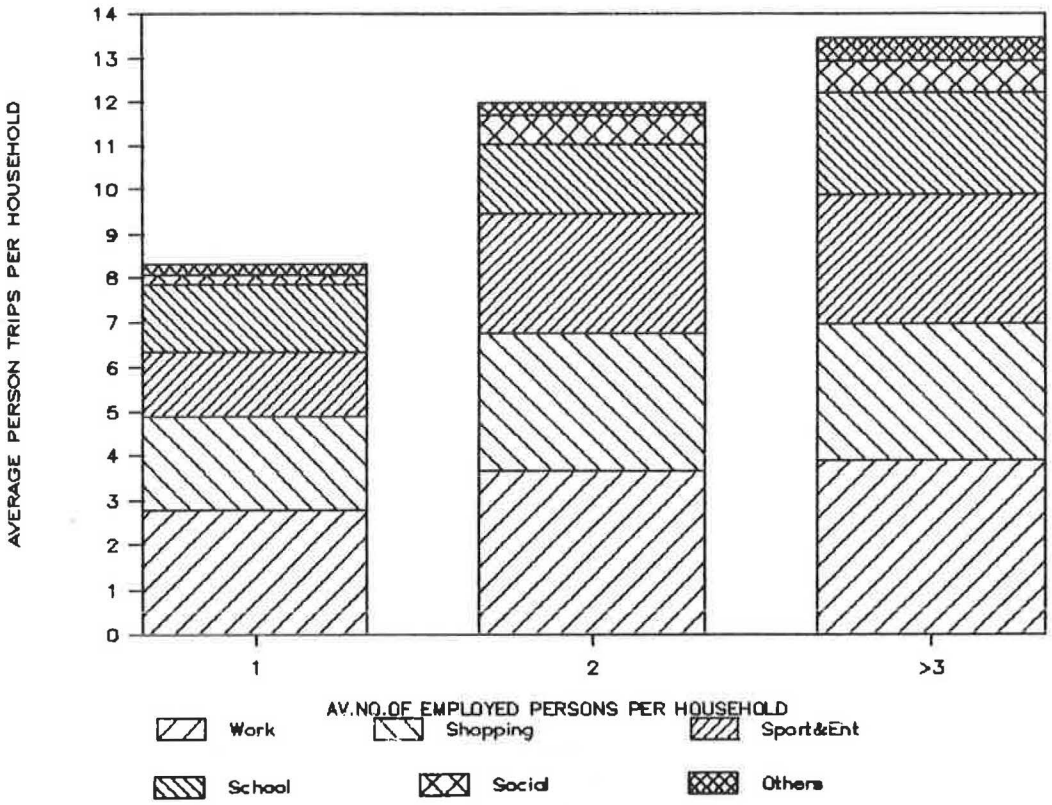

FIGURE 4 Household trip rate by number of employed persons per household and trip purpose.

shopping trips was 8.27 and the total for sports and entertainment trips was 7.06. Because incomes earned by employed members of the household, other than the head of the household, are not usually considered to be part of the "legitimate" household income, there is a tendency to use such incomes to satisfy personal wants; hence, the increase in shopping and sports and entertainment trips. Social trips were underrepresented because such trips are linked to trips undertaken to satisfy sporting and entertainment needs. An example is calling on a friend to go to a movie or to a soccer match.

Mode of Travel

The influence of household size, income, and car ownership on mode of travel was analyzed. The results are shown in Table 2 and illustrated in Figures 5–7. Generally, trotro or bus trips and walking trips increased with household size. Trotro trip rates increased steadily from 1.51 to 2.84 trips per household as household size increased from 1 to 2 persons to 11 or more persons. A similar trend is observed in bus trip rates. The majority of households interviewed live in low- and middle-income residential units, so this finding indicates the importance of public transportation services (i.e., trotro and bus) in Kumasi and their impact on the daily travel patterns of the majority of household members. For large households, taxi and car trips tended to decrease. The decline indicates that resources for travel in larger families influenced modal choice in favor of the cheaper and more available modes (trotro, bus, and walking) and against the more expensive ones (taxi and car). Figure 5 shows this trend.

As can be seen from Figure 6, which illustrates the relationship between household income and modal choice, more car trips were made as household income increased. However, trotro trips decreased for households with income levels of ₵2,401 or more. For low-income households earning ₵2,400 or less there was a general increase in household trip rates, but as the level of income increased, trotro and motorcycle trip rates tended to decrease.

Surprisingly, bus trip rates increased and taxi trip rates dropped for households earning more than ₵4,800. In most developing countries, taxis are operated not for individual rides as they are in the developed countries but for shared rides. In fact, in most cities, the number of available and operative taxis is few relative to the number of riders, so riders are willing to share and pay separately for the same taxi ride. In this situation, taxis are operated like jitneys following a fixed or semifixed route and schedule and charging the same fare. The only difference is that taxis usually charge a higher fare and carry a maximum of 5 persons at a time, whereas jitneys carry 10 or more persons depending on the type of chassis. The bus is usually cheaper and sometimes cleaner and more comfortable than the taxi. This may be why higher-income households in Kumasi used the bus more than the taxi system at the time of the survey. Nevertheless, the trend depicted in Figure 6 indicates the relationship existing between household income and mode of travel. The study indicates that households prefer to use the mode of travel charging fares that are consistent with their levels of income.

Figure 7 shows household trip rates stratified according to the number of cars owned. Generally, the proportion of daily trips by car, bus, and taxi varied according to the number of cars owned. Trotro trips were stable with increasing car ownership. Contrary to what may exist in developed countries, car trips were made by households that did not own cars; in

TABLE 2 HOUSEHOLD TRIP RATES BY MODE OF TRAVEL

Household Category		Car	Trotro	Bus	Taxi	Motorcycle	Walk
Household Size	1 - 2	0.64	1.51	0.75	0.36	0.09	0.11
	3 - 4	0.48	1.89	0.81	0.42	0.18	0.24
	5 - 6	1.31	1.59	1.39	1.12	0.37	0.53
	7 - 8	1.42	1.85	1.52	1.16	0.31	0.59
	9 - 10	0.85	2.32	1.65	1.19	0.18	0.49
	11 +	0.22	2.84	1.93	0.58	0.11	0.58
Household Income (in Cedis)	0 - 1,200	0.41	1.57	0.82	0.30	0.03	0.16
	1,201 - 2,400	0.40	1.69	0.96	0.46	0.08	0.17
	2,401 - 3,600	0.59	1.95	1.41	1.23	0.29	0.13
	3,601 - 4,800	1.16	1.78	1.29	1.34	0.32	1.10
	4,801 - 6,000	2.44	1.52	1.30	1.82	0.19	0.15
	6,001 +	2.95	1.34	1.57	1.72	0.02	0.10
Car Ownership	0	2.08	1.23	1.31	0.91	0.39	0.96
	1	2.50	1.39	1.81	1.01	0.82	1.23
	2	2.52	1.36	1.89	1.02	0.86	1.32
	3 +	2.45	1.36	1.91	1.07	0.87	1.45

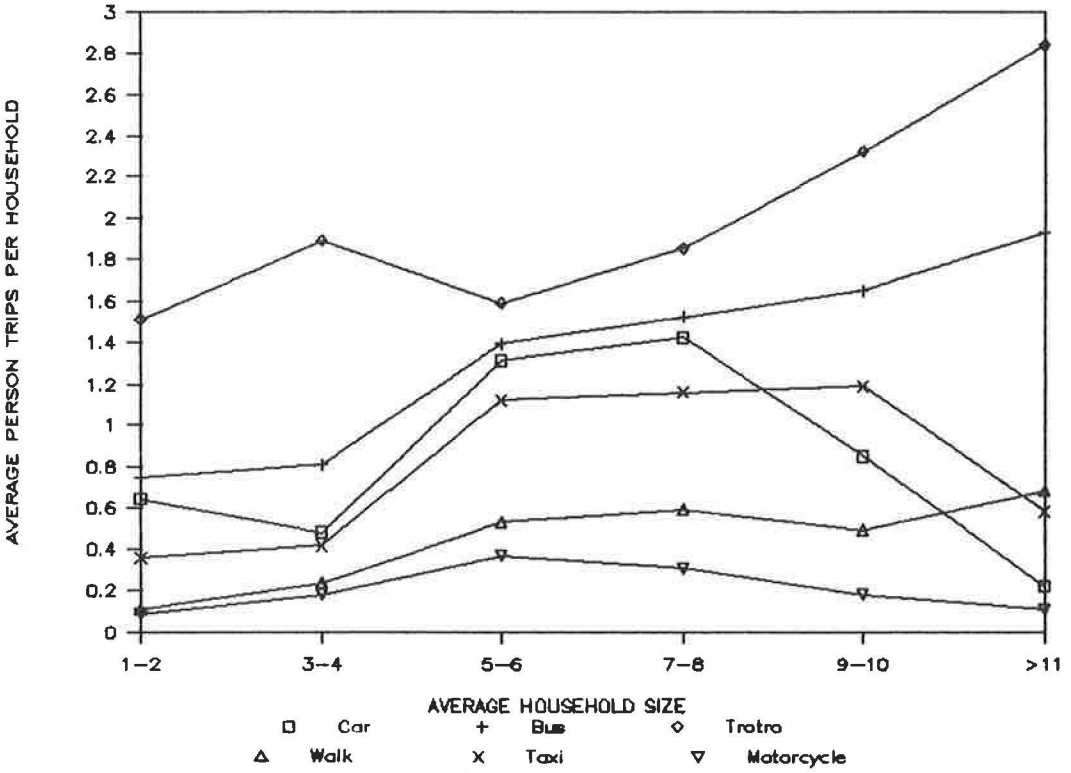

FIGURE 5 Household trip rate by household size and mode of travel.

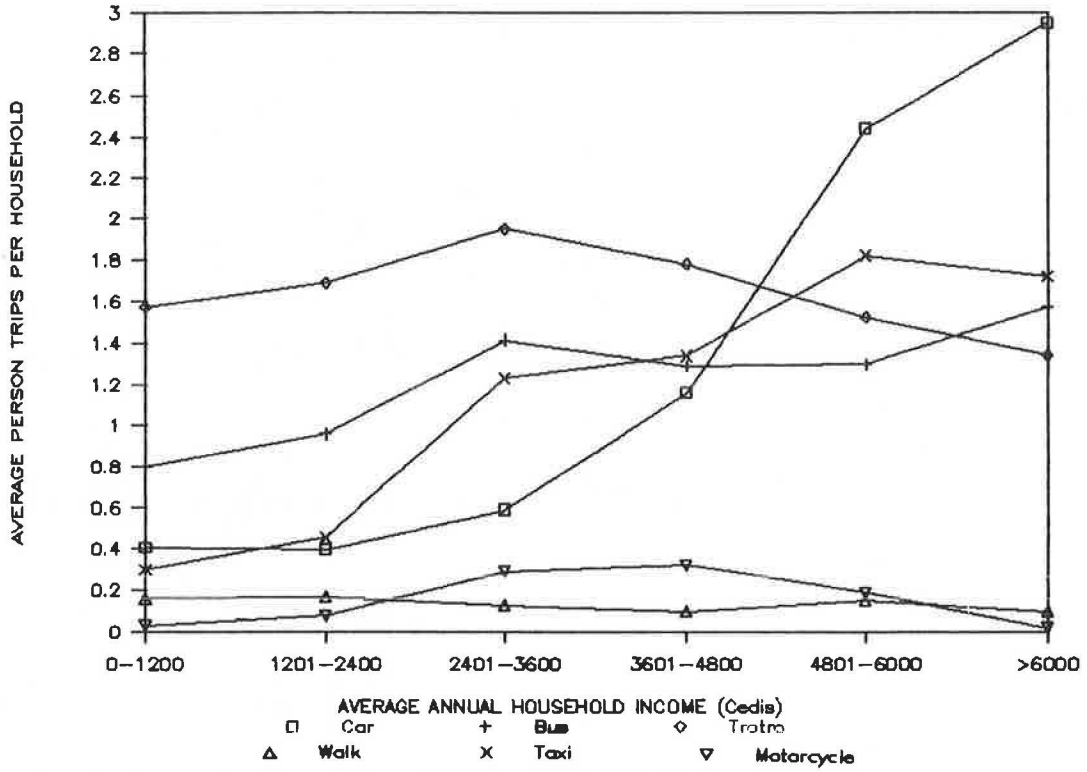

FIGURE 6 Household trip rate by household income and mode of travel.

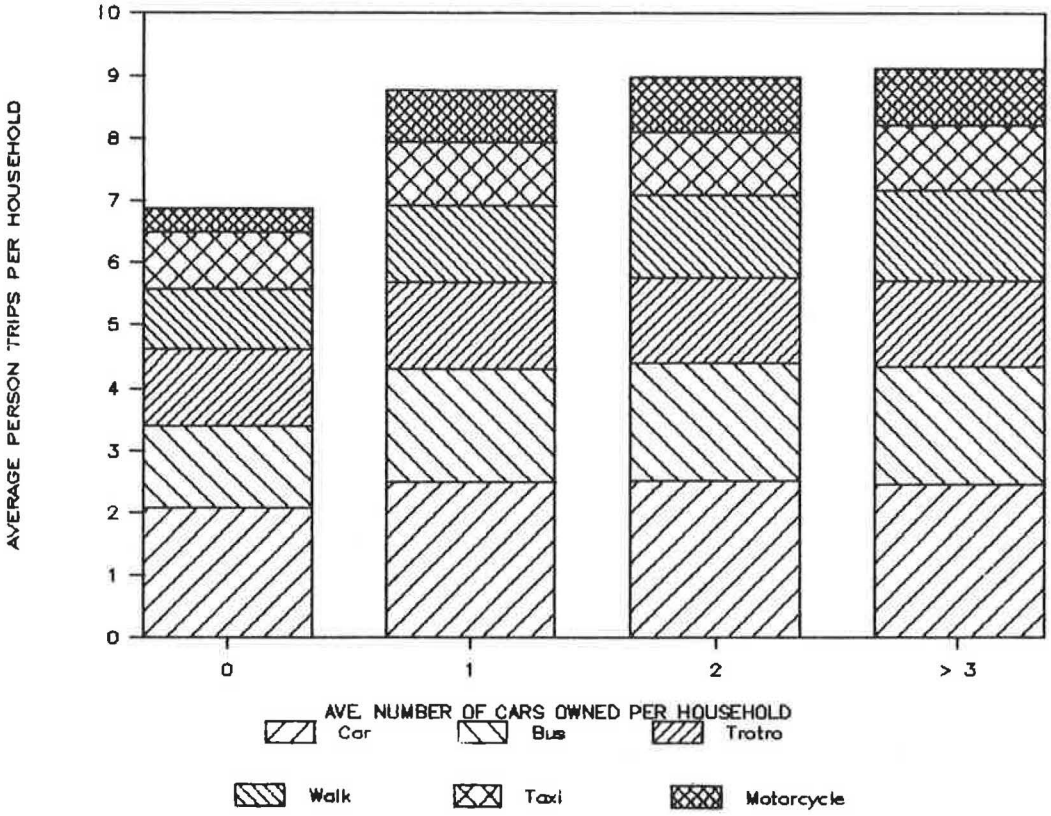

FIGURE 7 Household trip rate by car ownership and mode of travel.

fact. car trips were relatively greater in number than trips made by other modes of travel with the possible exception of walking trips. One possible explanation is that these households have been enjoying the use of cars owned by other households living in the same house. In other words, non-car-owning household members get lifts from car owners living in the same house. Although car-owning households made more car trips, a significant proportion of the members also used bus, trotro, and taxi services.

Total Reported Trips

The total trips reported in this study are summarized under two classifications—trip purpose and mode of travel. Figures 8 and 9 provide these summaries. Figure 8 indicates that the order of importance of trip purpose in the household trip generation process was work, shopping, school, sports and entertainment, social, and other. Work trips contributed 28.8 percent of the total household trip rate, shopping contributed 20 percent, and school trips contributed 17.1 percent. Whereas almost every household made trips to satisfy work and shopping needs every weekday, not all did so for school, social, and sports and entertainment. On the whole, trips were fairly distributed among the various purposes of travel.

Figure 9 indicates that trotro trips accounted for 32 percent of the total household trip rates, followed by bus (23 percent), car (19.5 percent), and taxi trips (17 percent). Walking and motorcycle trips contributed 4.9 and 3.2 percent, respectively. The high percentage of trips made with trotro is partly explained by the availability, convenience, and affordability of trotro service to a majority of the urban population. The choice of mode is influenced not only by ability to pay but also by the purpose of the trip.

CROSS-CLASSIFICATION ANALYSIS

A one-way ANOVA was performed to determine the variables that appear to have the strongest relationships to trip making by purpose and mode of travel. The results were used to determine the best grouping of data for the cross-classification analysis. Details of the runs of the ANOVA by trip purpose are presented in Table 3. From the table, the following conclusions were drawn.

Household size performed better than household income and number of employed persons for all trip purposes except work and sports and entertainment trips. It was a significant variable for all modes of travel. It ranked first in significance across most travel modes.

Household income did not perform satisfactorily across a majority of trip purposes. It was significant for unclassified trips and sports and entertainment trips. Similarly, it was only significant for taxi and bus trips.

Number of employed persons was a consistently significant variable for most trip purpose groups. It was significant for work, shopping, and sports and entertainment trips.

The results of the ANOVA by mode of travel are not provided here because they were used primarily to explore further variations in the analysis of variables. From the analysis, household size was found to be significant across all trips (both

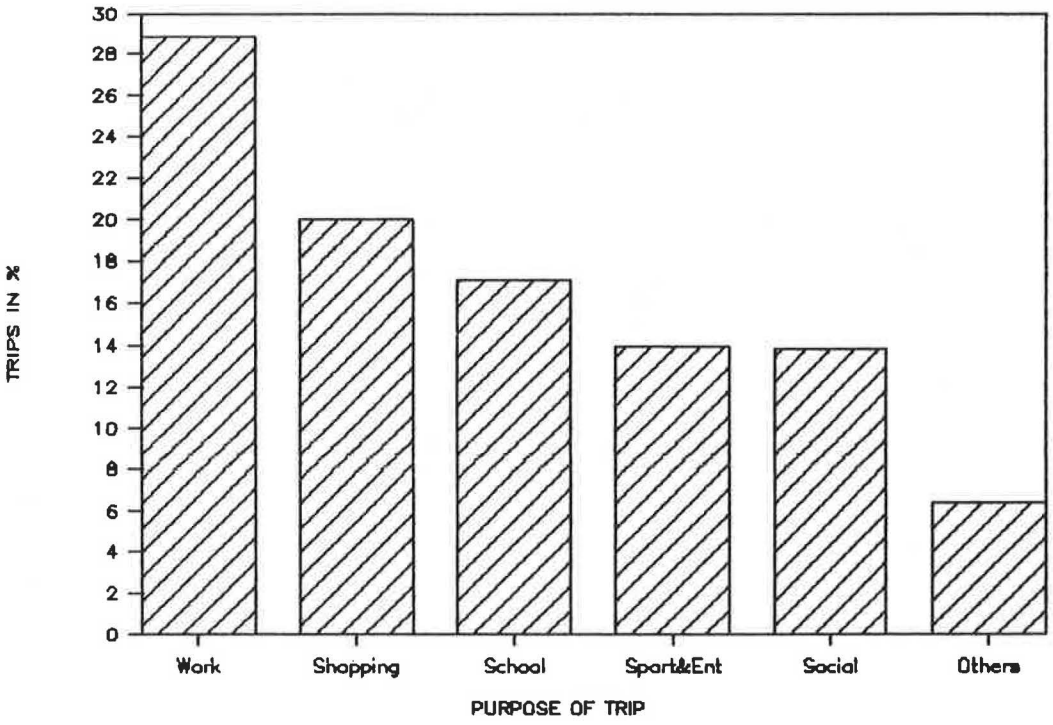

FIGURE 8 Total reported trips by trip purpose.

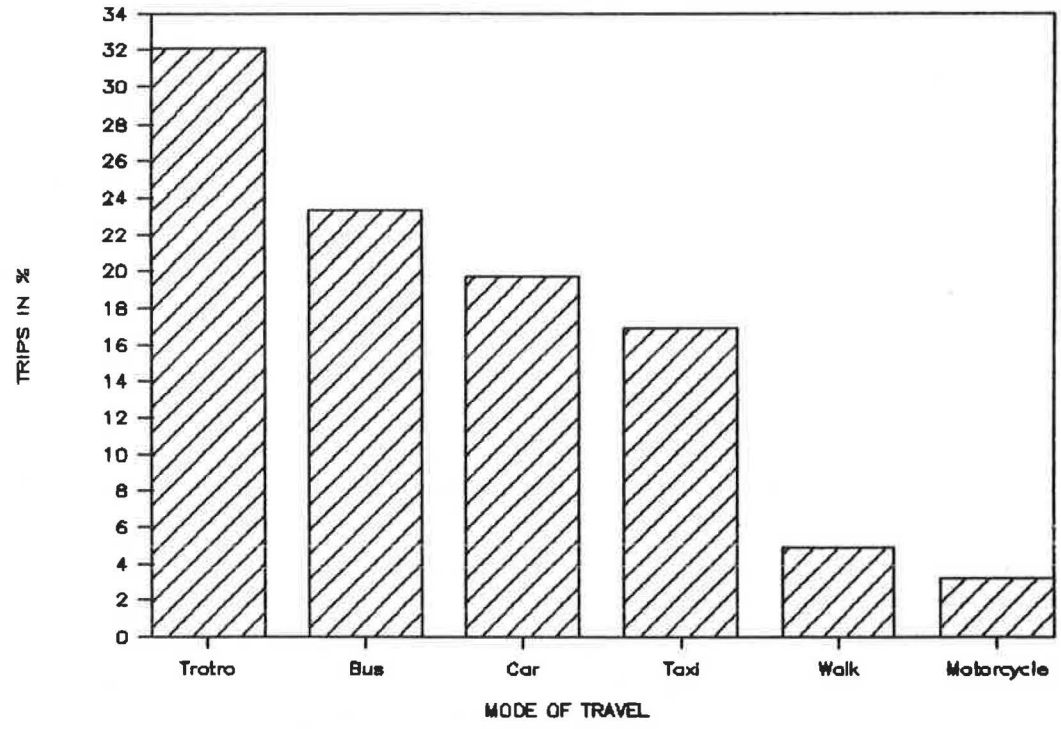

FIGURE 9 Total reported trips by mode of travel.

TABLE 3 ANOVA RESULTS BY TRIP PURPOSE

Variable	Categories	Statistic	Purpose of Trip: Work	School	Shopping	Social	Sport and Entertainment	Other
Household Size	6	F	2.1	6.5	6.9	7.5	2.2	3.0
		df						
		SS (Between)	5	5	5	5	5	5
		SS (Within)	668					
		Significance	*b*	*a*	*a*	*a*	*b*	*a*
Household Income	6	F	2.1	1.9	2.0	2.1	3.4	4.7
		df						
		SS (Between)	5	5	5	5	5	5
		SS (Within)	646					
		Significance	*b*	*b*	*b*	*b*	*a*	*a*
Number of Employed Persons	3	F	6.8	2.0	5.2	2.1	5.1	2.2
		df						
		SS (Between)	2	2	2	2	2	2
		SS (Within)	659					
		Significance	*a*	*b*	*a*	*b*	*a*	*b*

F = F score SS = Sum of Squares, and df = degrees of freedom

[a]significance at 95 percent or beyond; [b]not significant at 95 percent or beyond.

motorized and nonmotorized). Household income was less significant than car ownership for all trip modes.

A comparison of the levels of significance of the variables in Table 3 indicates that household size and number of employed persons are the most significant variables for trip making. In addition, car ownership was found significant in the ANOVA analysis by mode of travel. Thus, they were chosen for further trip rate analysis. Household income was not significant compared with the other three variables because most of the trips were made to satisfy school, shopping, and work purposes. It was also not significant when acting simultaneously with car ownership. One reason for the low performance of household income when used simultaneously with car ownership is that, in the Ghanaian culture, owning one or more cars is a strong indicator of the economic status of a household. Other trip generation studies, carried out in a culture in which ownership of a car is not related strongly to level of income, indicate contrasting results (*7*,*8*). This is because in the latter case a large market for used cars of varying conditions and price ranges usually exists, whereas in the former case primarily new or remodeled automobiles are sold at prices far above the means of the average worker. One way to improve the significance of the household income variable would be to use the total household income or per capita income.

The simple cross-classification rates shown in Tables 4–6 provide a comparative analysis of trip rates of the most significant variables. Table 4 indicates that high trip rates were associated with large households that own two cars and have seven or more members.

There were empty cells for one- or two-member households with two or more cars. The same observation applies to households with three or more employed persons, as indicated in

TABLE 4 SIMPLE CROSS-CLASSIFICATION TRIP RATES: CAR OWNERSHIP VERSUS HOUSEHOLD SIZE

Car Ownership	Household Size: 1-2	3-4	5-6	7-8	9-10	≥ 11
0	0.51	0.61	1.39	1.72	1.59	1.60
1	0.01	0.25	1.95	2.00	1.08	0.98
2	--	0.71	1.89	2.20	2.51	2.39
≥3	--	0.03	1.45	2.40	1.99	1.84

TABLE 5 SIMPLE CROSS-CLASSIFICATION TRIP RATES: NUMBER OF EMPLOYED PERSONS VERSUS HOUSEHOLD SIZE

No. of Employed Persons	Household Size 1-2	3-4	5-6	7-8	9-10	≥ 11
1	0.81	1.21	1.08	0.87	0.45	--
2	0.19	3.18	2.82	3.11	1.71	0.94
≥3	--	--	1.56	2.14	1.12	1.04

TABLE 6 SIMPLE CROSS-CLASSIFICATION TRIP RATES: NUMBER OF EMPLOYED PERSONS VERSUS CAR OWNERSHIP

No. of Employed Persons	Car Ownership 0	1	2	≥ 3
1	1.41	2.10	2.09	0.41
2	1.98	3.11	3.23	2.42
≥3	2.00	2.99	3.04	1.82

Table 5. This indicates that large households (with three to eight members) are a feature of the household structure in Ghana. These households had the highest trip rates. A household size larger than eight did not significantly influence trip frequency, so further evidence is needed before household size groupings above eight can be used.

Table 6 indicates that trip rates were higher in households with one or two workers who own one or two cars. The rates vary from 2.09 to 3.23.

CONCLUSION

Trip generation procedures adopted in developed countries may not apply to developing countries because the factors influencing trip-making behavior of household members are different. The type of variables, how they are defined and structured for trip rate analysis, and the limitations of the analytic technique in relation to socioeconomic values must be examined for study results to be useful.

The analysis indicates that owing to the extended family system in Ghana, household sizes were found to be large and influential in trip generation, although trip rates were not significantly increased for household sizes larger than eight. The prevalent household trips were found to be work, shopping, and school trips. The trip rate for such trips increased with increasing size of household. Similarly, the larger the household, the greater the trotro, bus, and walking trips. The two other significant variables were number of employed persons and car ownership. Trips for sports and entertainment, social, and other reasons such as to transact personal business increased with income. However, when household income was included in the same model with car ownership, its influence on trip making was significantly reduced. As urbanization increases and household travel patterns become more complex, a wider income classification that includes incomes of other household members will be needed in the analysis of nonbasic trips.

Because household size is the strongest determinant of trip making, the influence of the structure (i.e., number of dependent nieces, cousins, etc., working dependents, and number of dependent children and adults) of large household sizes (between four and eight members) on trip frequency must be explored. The usefulness of ANOVA is demonstrated in this kind of analysis, and if a higher level of sophistication is needed, the MCA technique can also be employed.

The results of the earlier version of this study using linear regression corroborate some of the findings of this analysis when the cross-classification method is used. For instance, household income had low significance levels in both cases, and car ownership and the number of employed persons were both found to be significant variables. However, the cross-classification method used here improves significantly the influence of the household size variable, which earlier showed a nonlinear relationship to the average number of trips per household. This method also allows a comparative analysis of selected household variables to be made. Therefore, it holds much promise for future trip generation studies in developing countries.

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