Mobility patterns of motorcycle and moped riders in Greece

By:

George Yannis, PhD – corresponding author
Assistant Professor,
Department of Transportation Planning and Engineering,
National Technical University of Athens,
5, Iroon Polytechniou str, 15773 Zografou, Greece,
tel.: +30 210 7721326, fax: +30 210 7721454,
e-mail: geyannis@central.ntua.gr

John Golias, Prof.
Professor,
Department of Transportation Planning and Engineering,
National Technical University of Athens,
5, Iroon Polytechniou str, 15773 Zografou, Greece,
tel.: +30 210 7721276, fax: +30 210 7721454,
e-mail: igolias@central.ntua.gr

Ioanna Spyropoulou, PhD
Research Associate,
Department of Transportation Planning and Engineering,
National Technical University of Athens,
5, Iroon Polytechniou str, 15773 Zografou, Greece,
tel.: +30 210 7722889, fax: +30 210 7721454,
e-mail: iospyrop@central.ntua.gr

Eleonora Papadimitriou, MSc
Research Assistant
Department of Transportation Planning and Engineering,
National Technical University of Athens,
5, Iroon Polytechniou str, 15773 Zografou, Greece,
tel.: +30 210 7721380, fax: +30 210 7721454,
e-mail: nopapadi@central.ntua.gr

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ABSTRACT
This paper investigates the mobility patterns of powered two-wheeler riders in comparison to those of passenger car drivers in Greece, a country where an increased two-wheeler ownership and related traffic is observed. A nationwide travel survey targeted at two-wheeler and passenger car active drivers was carried out on that purpose. The results of the survey were exploited in two ways; first, the usage of the examined vehicle types in Greece was investigated in relation to driver characteristics, through the calculation of the respective sample distributions. The results demonstrated a clear difference between vehicle ownership rates and vehicle usage rates per vehicle type. Moreover, the mobility patterns of each vehicle type were comparatively analyzed, on the basis of the average yearly mileage travelled, in relation to driver (age, gender, experience), vehicle (engine size) and type of trip (weekday/ weekend) and road environment (area type, lighting conditions, road type), providing interesting results. In particular, driver gender, age and experience appear to be a stronger determinant of mobility patterns than vehicle type. On the other hand, different mobility patterns amongst vehicle types in different road environments were identified, suggesting that mopeds and motorcycles are preferred for particular types of trips (e.g. travelling in residential areas and weekdays during daytime) whereas passenger cars may be used in all cases.

1. INTRODUCTION

Motorcycles are a mode of transport that has distinct characteristics to those of passenger cars, and comprise a discrete vehicle category. The main differences are the absence of separation between the rider and the driving environment, its small width and its movement on two rather than four wheels. These characteristics make motorcycles appealing to a significant amount of the driver population.

The absence of separation of the motorcyclist from the driving environment provides a feeling of freedom to the rider and can make driving a quite enjoyable and desirable experience. Furthermore, the small width and movement in two wheels allow for great manoeuvre-ability when driving. In many urban areas, motorcycles tend to move on the lane boundaries rather than within them as the rest of vehicles do *(1)*. This makes motorcycle movement more efficient time-wise. Because of their characteristics, motorcycles can play a significant role in achieving more efficient road and parking space utilisation, reduced emissions and faster access *(2)*. Furthermore, the price of a motorcycle is usually much less than that of a passenger car allowing population with smaller income and especially youngsters – in combination with the fact that in several countries, under 18 ages are allowed to drive only small motorcycles – to acquire a transport mode.

For these reasons the motorcycle has become a quite popular mode of transport. Its wide use is mainly encountered in countries with warm weather conditions (e.g. Southern European countries) *(3)* and/or high population density or low income (several countries in Asia) (4). As the motorcyclist is not separated from the driving environment, low temperatures or rain contribute to a difficult and not comfortable environment for motorcycle driving. Southern European countries offer "friendlier" weather conditions for enjoyable driving, and hence safer driving conditions.

Even though motorcycles are most common in these specific areas, their popularity seems to be increasing as their growth follows a similar or even higher growth rate than that of

the passenger cars in most European countries. This growth in popularity makes the investigation of several aspects of motorcycle traffic a necessity.

Motorcyclists have been identified as a particular and vulnerable user category since they are characterized by distinct mobility patterns and their accident rates are particularly high *(5)*. This is a consequence of several factors including their driving behaviour, interaction with other vehicles and lack of separation with the driving environment. Hence, a significant amount of research has been conducted on the field of road safety of motorcyclists *(6,7,8)*. Research has also been conducted on the environmental aspects of the use of motorcycles *(9,10)*. Motorcycle traffic in relation to its characteristics and the implementation of traffic management regulations has also been a recent topic of research *(11,12,13)*. Furthermore, a number of studies address the issue of motorcycle ownership *(14,15)*. However, not much research has been conducted on the mobility patterns of powered two-wheelers. This paper focuses on one mobility aspect of mopeds and motorcycles – namely, the annual driven mileage – and investigates the different patterns that may be identified in relation to different driver, vehicle and trip characteristics.

2. OBJECTIVE AND METHODOLOGY

This paper discusses the driving habits of moped riders and motorcyclists in Greece expressed in annual driven mileage and compared to these of passenger car drivers. This parameter (annual driven mileage) was preferred to other mobility measures (number of trips etc) as it is one of the least examined mobility measures. Furthermore, it is widely used as a measure of traffic risk exposure.

In order to explore mobility patterns of the various groups of drivers in different conditions, a standard methodology was used in accordance to the common practice reported in the literature *(16,17)*. In particular, a nationwide CATI (computer assisted telephone interviewing) survey was conducted in 2004 in which drivers were asked to report the distances travelled during recent trips, as well as the characteristics of these trips. It should be noted that, although it is well known that the results of this particular method may bear a self-reporting bias, this is not expected to significantly affect the general trends reflected by the comparisons among groups (i.e. the self-reporting issue is considered to be equally present in all drivers).

In the following sections, the results of this survey are analysed. First, the usage of two-wheelers is investigated in relation to driver characteristics such as age, experience and gender. Then motorcycle mobility is presented and discussed in relation to driver, vehicle and driving environment characteristics. The results of this study can provide insight on the comprehension of specific aspects of the driving habits of motorcyclists. Such knowledge can be exploited for the design of efficient strategies such as those targeted to the improvement of motorcyclist road safety (18).

A Simple Random Sampling (SRS) technique was used in order to collect the necessary information. The only quota applied in the sampling process concerned the nationwide coverage of all area types, including large metropolitan areas, urban areas and rural areas. The survey target population was all active drivers of passenger cars or two-wheelers, aged above 16 years. Active drivers were defined as driving license holders who had used their vehicle in the past six months and in the previous day. Respondents were randomly picked out of the national telephone register of Greece, within the quota described above.

First, the respondent was asked whether he was an active driver, and if his answer was positive the survey continued. The questionnaire comprised three parts. In the first part, general questions on the respondents' characteristics were asked, such as gender, age, education etc.

Respondents were then asked of the number and type of vehicles they use; if they used more than one (e.g. a passenger car and a moped) the interviewer chose randomly one of the vehicles and proceeded with the interview on this vehicle. The following two parts of the questionnaire involved this particular vehicle. Questions on the second part of the questionnaire concerned vehicle characteristics such as vehicle age, engine capacity etc. Finally, the latter part of the questionnaire comprised questions on the length of trips (in terms of distance travelled) of the respondent. They were also asked of the time of day, day of week and the type of road network in which the trips were made.

A total number of around 6 000 contacts were made, including unwilling to respond or unsuitable cases (i.e. not active drivers). The final sample used in the analysis included 2,500 active passenger car drivers and two-wheeler riders that responded in most of the questions. However, age, gender and vehicle were available for all contacts, and this information was used for the validations of the distributions of the final (smaller) sample. The survey was carried out during the period May-June 2004, a period which can be considered representative of the yearly patterns, as all kinds of trips (work-related, recreational, long distance etc.) could be observed. Moreover, this period presents only marginally better weather conditions (slightly higher average temperature and slightly lower rainfall levels) compared to the average yearly weather conditions in Greece and therefore no significant difference in vehicle traffic is expected.

3. TWO-WHEELERS USAGE IN GREECE

In this section, the usage of mopeds and motorcycles is estimated on the basis of the survey sample distribution of the respective active drivers, which is representative of the actual active driver's population.

The majority of the active driving population in Greece, 85.5%, uses the passenger car as a transport mode, whereas the rest 14.5% uses mopeds (5.6%) and motorcycles (8.9%). It must be noted that the use percentage of motorcycles is lower than the ownership percentage in Greece (18). This indicates that powered two-wheelers might be transport modes serving secondary needs. Hence, a considerable number of respondents who own both a motorcycle or moped and a passenger car regard the latter as their main transport mode.

The distribution of the usage of the three examined transport modes in relation to driver age is presented in Figure1.

FIGURE1. Passenger Car, Motorcycle and Moped Usage in Relation to Driver Age

The age for obtaining a traffic licence in Greece is 16 years for mopeds and 18 years for the rest of the vehicle categories, including motorcycles and passenger cars. Hence, drivers aged 16 and 17 years old only use mopeds. Half of the drivers aged 18-20 years old use mopeds and motorcycles, and this is considered to be a quite high proportion. This percentage falls to 22% for drivers aged 21-24 years. In general, drivers aged 16-24 years old are often referred to as “young drivers” (19). This group is characterised by particular behaviour, such as the increased use of two-wheelers, but also varying mobility patterns, and more risk-taking driving behaviour (20).

The use of mopeds and motorcycles generally decreases with age, as is expected. Motorcycles are favoured against mopeds for age groups 25-34 and 35-54, whereas mopeds are favoured against motorcycles for younger driver age groups 18-20 and 21-24. Finally, for older

age groups – 55-64 and over 65 (elderly drivers, (21)) – use percentages of mopeds and motorcycles are similar.

The distribution of the use of mopeds and motorcycles highlights the different preferences between male and female drivers. From the data, a 20% of the male driver population was recorded to use mopeds and motorcycles whereas the corresponding percentage was 8% for the female driving population. Males prefer motorcycles to mopeds, whereas females show a slight preference to mopeds.

4. TWO-WHEELERS MOBILITY IN GREECE

4.1 Driver age, gender and experience

In this section, the mobility patterns of Greek active passenger car drivers and two-wheeler riders are analyzed. From the results of the nationwide CATI survey, in which the distance travelled on the previous day was reported, the average yearly number of vehicle-kilometres travelled was calculated for different road user, vehicle and road environment characteristics. Driver mobility in relation to driver age is presented in Figure2.

FIGURE 2. Mileage Driven (km) in Relation to Driver Age

Mobility of motorcyclists follows the same pattern as for passenger car drivers, a pattern according to which average yearly mileage first increases and then decreases with age, except for the cases elderly drivers for the motorcycle category. Further analysis indicated that the sample of motorcycle elderly drivers was quite low and the resulting calculated mileage has a high variance. Mobility of moped riders follows a different pattern. Mileage driven generally reduces with age. There is, however, a significant increase of vehicle-kilometres for age group 55-64. Average distances travelled by this particular age group are less only than those travelled by drivers aged 16-17 years old. This describes a phenomenon encountered in non-urban areas where quite frequently older drivers use mopeds and motorcycles. Results specify a similar way of motorcycle and passenger car use in relation to driver age groups, which is clearly different to moped use. Highest mobility for mopeds is observed for age group 16-17, at which drivers have no alternative private transport mode. Motorcyclists drive more between 25-34 years old and passenger car drivers between 45-54 years old. The latter may be a consequence of the increase of family-oriented trips.

Average yearly mileage travelled by moped and motorcycle riders and passenger car drivers in relation to driver gender is presented in Table1.

TABLE 1. Mileage Driven in Relation to Driver Gender

As for the mobility distribution of the examined transport modes, the mileage distribution of the female driving population is significantly lower to that of the male population. The reduction is similar for all three modes, indicating that there is no difference in their relative use between men and women.

The distribution of the average yearly mileage driven in relation to driver experience is presented in Figure3.

FIGURE 3. Mileage Driven (km) in Relation to Driver Experience

Experience is defined as the duration of holding a car licence; the last category that is examined is over 10 years which corresponds roughly to drivers aged over 28 years old. Mileage driven in relation to driving experience presents a completely different pattern between mopeds and motorcycles. For mopeds it obtains its highest value for riders holding a driving licence for less than one year. The reason for this is, as noted earlier, that mopeds are used extensively by drivers aged 16-17 years old who are not allowed to drive any other vehicle. Mileage driven by mopeds presents slight fluctuations with experience, for all other categories (durations) of license holdership.

For motorcycles, average mileage driven fluctuates with driving experience. It increases for the first two licence holdership categories. This can be explained when considering that, in most cases, a limited experience is associated with younger age; an increase in experience by 1-2 years leads in increase of the average yearly distance travelled by young individuals, through improved skills and confidence. Accordingly, driving experience exceeding 3-5 years corresponds to somewhat older individuals – as indicated from the data – who may shift to driving passenger cars and/or use the motorcycle as a secondary private transport mode.

Passenger car drivers tend to drive more with experience, which is in accordance with the above results.

A combined investigation of drivers age and experience would be interesting within this context, however further desegregation of the data led to insufficient sample for some categories and consequently the analysis was not carried out. Results however indicated that for motorcycle riders driver age and driver experience cannot be unified, as it seems that a significant number of motorcycle riders do not hold a driving licence at 18-20 years old.

4.2 Vehicle engine size

A parameter that may also affect mobility is the engine size of the vehicle. The distribution of annual driven mileage in relation to motorcycle engine size is presented in Table2.

TABLE 2. Mileage Driven in Relation to Vehicle Engine Size

The computed values of annual mileage indicate that a relationship between driven mileage and vehicle engine size exists. In particular, riders with “stronger” motorcycles tend to drive more. The main reason behind this pattern is that motorcycles of higher engine size can perform better (faster and safer, especially for high engine size ones) and are more comfortable for driving longer distances. As a consequence riders with such motorcycles would end up driving more. In addition, a significant proportion of riders who would choose higher engine size motorcycles are expected to consider driving a thoroughly enjoyable experience and hence an aim on its own.

4.3 Time of day and day of week

The habits of the drivers of the three investigated transport modes on weekdays and during the weekend are illustrated in Table3.

TABLE 3. Mileage Driven in Relation to Day of the Week

The values presented in Table3, involve the yearly mileage driven on weekdays and weekends as well as the average yearly mileage driven on a weekday and on a day during the

weekend. Mileage driven during the weekend is lower to that driven on a weekday for all two-wheelers and slightly more for passenger cars. More specifically, moped riders and motorcyclists drive around twice more on an average weekday than on an average day during the weekend. The corresponding value for passenger car drivers is much less, and is only 1.1 times more in weekdays than in weekends. Moped riders also drive slightly less during the weekend than on weekdays in relation to motorcyclists. Mopeds are used mainly for "everyday" trips mainly work or school (for ages of 16-17 years) related, motorcycles are used more than mopeds for other types of trips as well, whereas for non-work related trips passenger cars are preferred. Thus, a proportion of drivers, who use two-wheelers on weekdays (probably to achieve lower travel times), shift to passenger cars for trips during the weekend. Assuming that the majority of trips on weekdays are work related and during the weekend leisure related, two-wheelers can be identified as "work-oriented" transport mode, in Greece. The assumption that in western countries they are used for leisure trips *(6)* is contradicted by these data.

The same argument should be justified by vehicle use during daytime and night-time. Average mileage driven in relation to the time of day is presented in Table4.

TABLE 4. Mileage Driven in Relation to Time of the Day

Mileage driven during the night demonstrates a reduction for all three examined modes. Daytime was considered to be from half hour before sunrise until half hour after sunset. Daytime trips mainly consist of work related trips whereas night-time trips are mainly comprised by leisure trips. The survey took place during May and June, hence night-time trips may have included a small number of work-related trips, as well as leisure trips. Mileage driven during daytime is around 83.6%-84.3% of the total mileage driven during the whole day, and no particular differences are encountered between the three different transport modes. Evidence provided by this data cannot confirm the above specification of two-wheelers as "work-orientated" transport modes.

Further analysis was conducted to check the reasons for the similar attitude of average mileage driven in relation to the time of day that was observed. Table5 illustrates mileage driven yearly on weekdays and weekends and mileage driven on average on a weekday and during the weekend both during daytime and night-time.

TABLE 5. Mileage Driven in Relation to Day of the Week and Time of the Day

Motorcycles and mopeds were not examined as two different vehicle categories in this case, as mopeds and motorcycles demonstrated similar mileage patterns in relation to the day of week and time of day. For passenger cars 85.6% comprise the proportion of mileage driven at daytime on a weekday and 79.3% at daytime during the weekend. The corresponding percentages for two-wheelers are 87.6% on weekdays and 75.1% at weekends.

In terms of the yearly driven mileage on an average day, during the weekend there is a greater reduction during the night than on weekdays for two-wheelers than for passenger cars.

The majority of mileage driven by both modes is during daytime on a weekday. This proportion is greater for two-wheelers than passenger car drivers. Second, is mileage driven during daytime at the weekend. In this case the proportion is higher for passenger cars to two-wheelers. The results reinforce the definition of two-wheelers as a mainly "work-oriented" transport mode in Greece.

4.4 Type of area and type of road network

Next the type of areas in which drivers drive is investigated. Table6 illustrates driven mileage in and out of residential areas for the examined modes. It is noted that a more detailed classification of the urbanization level was not examined, as this has been applied as a sample quota and therefore the within-region results might not be comparable to the cross-region trends. Consequently, a more general inside/outside residential area classification seems more appropriate, especially within the framework of a macroscopic analysis as the present one.

TABLE 6. Mileage Driven (km) in Relation to Type of Area

Mileage driven in residential areas comprises around 87% of the total average mileage for mopeds. This might be a result of several attributes. First, a significant proportion of driven mileage arises from 16-17 year old riders. Such trips would include mainly trips related to school or friends' visits, hence trips that are within short distances and in residential areas. One other reason for this low proportion is that outside of residential areas vehicles might drive faster, and such road networks would be less safe for a "weak" vehicle as the moped and therefore avoided.

Motorcyclists drive also mainly in residential areas, and the corresponding proportion of mileage driven on such trips is 85.3% of the total mileage. Road safety factors and preference on shorter trips *(6)* contribute to this high percentage, however to a lower degree compared to mopeds. In fact, motorcycles may present improved performance due to higher mass and cubic capacity, allowing for speeding and manoeuvring, and therefore better adaptation to the requirements of driving outside residential areas. Last, mileage driven by passenger cars in residential areas comprises only 46.8% of the total mileage. This analysis can lead to the conclusion that the passenger car is considered to be the "primary" mode, and it is favoured on longer distances to two-wheelers.

Mileage driven on motorways by moped riders, motorcyclists and passenger car drivers is also examined and presented in Table7.

TABLE 7. Mileage Driven (km) in Relation to Type of Road

Average mileage driven on motorways constitutes only 4.5% of the total mileage for mopeds. This proportion is doubled for motorcycles (10.2%) and is six times greater (29.9%) for passenger cars. Road safety issues comprise a contributing factor for this difference. Other factors include the fact that passenger cars can obtain higher speeds, especially compared to mopeds and low engine capacity motorcycles and can provide a more comfortable journey.

Further analysis was conducted to check driving habits of two-wheelers in relation to road area type and engine capacity. Results indicated low (around 14% of the total) average values of driven mileage outside residential areas for engine capacity less than 270cc. This proportion increased to 20% for motorcycles over 270cc. A similar pattern, mileage increase with increase of engine capacity, was encountered for mileage driven on motorways. The proportion of mileage driven on motorways is less than 10% for motorcycles up to 270cc and around 15% for motorcycles 270-730cc. Hence, for greater distances and high speed roads "stronger" motorcycles are preferred.

5. CONCLUSIONS

In this paper driving habits of two-wheelers – namely moped riders and motorcyclists – were investigated in relation to those of passenger car drivers, on the basis of the results of a nationwide travel survey. The primary variable of this analysis was the average yearly mileage driven.

Results show that average yearly mileage driven reduces with age for mopeds, with a further increase for elderly drivers. The pattern however of mileage driven by motorcycles in relation to age groups is similar to the one observed for passenger cars, indicating increased mobility of the intermediate age groups (i.e. 25-55 years) Average mileage driven by males and females presents the same pattern for all modes, with a reduced mobility for females.

Average yearly mileage increases with experience in the case of passenger cars, whereas no clear pattern could be identified for mopeds and motorcycles. Results indicate that non-experienced two wheelers are not necessarily young drivers.

Vehicle characteristics are also an important factor for rider mobility. Riders with 'stronger' motorcycles tend to drive more, due to both the increased motorcycle capabilities and also the rider inherit attitude towards driving.

Moreover, moped riders and motorcyclists drive more at weekdays than during the weekend and during daytime than night-time in relation to passenger car drivers. Hence, two-wheelers appear to serve in particular the needs of work-related trips (to and from work) rather than leisure-related trips.

Both moped riders and motorcyclists drive much less outside of residential areas and on motorways than passenger car drivers indicating that the usage of two-wheelers for shorter distances and on routes that are perceived to be safer is preferred, mainly due to lower driving speeds. Motorcyclists riding medium to heavy engine capacity vehicles drive more in non residential areas and on motorways, as this type of motorcycle provide faster speeds and improved performance.

Concluding, one might note that mopeds, motorcycles and passenger cars present some similarities and differences in the driver's driving habits. Motorcyclists and passenger car drivers can be generally considered to travel according to similar patterns in relation to their age and experience, whereas moped drivers present a completely different pattern. These similarities can be attributed to the general correlation between driver age and experience, and the effects of these parameters appear to be stronger than the effect of transport mode used. In particular, the flexibility of mopeds and motorcycles, as well as the fact that they may better fit the lifestyle and needs of young people, make them very popular among youngsters. However, as age increases, driving patterns appear to shift from the flexibility of mopeds and light motorcycles to the comfort of passenger cars or the better performance of heavier motorcycles. The pattern of the increased mobility of older and elderly moped riders should be also noted, which reflects a well-known picture of the Greek province.

Moped riders and motorcyclists have the same attitude in relation to the time and type of area where the trip is carried out, which is completely different to passenger car drivers. The latter reveals similar preferences of two-wheeler riders with respect to trip purpose and road safety factors. It can be said that most two-wheeler riders shall be exposed to the risk of driving on motorways, or during night-time, or any other riskier-perceived conditions, only in lack of other alternatives.

Summarizing, this research analysed the mobility patterns of two-wheeler riders in Greece in relation to a number of personal, vehicle and road environment characteristics, on the basis of data collected by means of a nationwide travel survey. The survey was carried out

according to the standard methodology and allowed for the estimation of the average yearly mileage of different categories of drivers under different driving conditions, providing a set of interesting results. The analysis presented above followed a one-dimensional or multi-dimensional structure, according to the type of question in each case. Future research shall focus on more combined analysis and to the full exploration of the multiple dependencies among the examined variables, for which modelling techniques shall be applied.

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TABLE 1. Mileage Driven (km) in Relation to Driver Gender

	Moped	Motorcycle	Passenger Car	Total
Male	4 600	7 149	18 278	16 001
Female	2 873	4 470	9 958	9 550
Total	4 205	6 845	15 025	13 695

TABLE 2. Mileage Driven (km) in Relation to Vehicle Engine Size (cc)

	Moped	Motorcycle	Passenger Car
< 50 cc	4 172		
50-115 cc		5 367	
116-269 cc		6 352	
270-730 cc		10 101	
>730 cc		11 993	
			15 013
Total	4 172	6 958	15 013

TABLE 3. Mileage Driven (km) in Relation to Day of the Week

Total yearly	Moped	Motorcycle	Passenger Car	Total
Weekday	3 514	5 685	11 038	10 143
Weekend	691	1 160	3 986	3 552
Total	4 205	6 845	15 025	13 695
Average day at				
Weekday	703	1 137	2 208	
Weekend	346	580	1 993	

TABLE 4. Mileage Driven (km) in Relation to Time of the Day

	Moped	Motorcycle	Passenger Car	Total
Daytime	3 511	5 767	12 602	11 489
Night-time	686	1 078	2 411	2 196
Total	4 198	6 845	15 013	13 685

TABLE 5. Mileage Driven (km) in Relation to Day of the Week and Time of the Day

Total yearly		Motorcycle	Passenger Car
Weekday	Daytime	4 379	9 447
	Night-time	662	1 589
Weekend	Daytime	787	3 155
	Night-time	261	822
Average day at			
Weekday	Daytime	876	1 889
	Night-time	132	318
Weekend	Daytime	394	1 578
	Night-time	130	411

TABLE 6. Mileage Driven (km) in Relation to Type of Area

	Moped	Motorcycle	Passenger Car	Total
Residential Areas	3 644	5 837	7 024	6 730
Non-residential areas	561	1 008	7 971	6 940
Total	4 205	6 845	14 995	13 670

TABLE 7. Mileage Driven (km) in Relation to Type of Road

	Moped	Motorcycle	Passenger Car	Total
Highway	190	697	4 466	3 893
Non-highway	4 016	6 147	10 478	9 733
Total	4 205	6 845	14 943	13 626

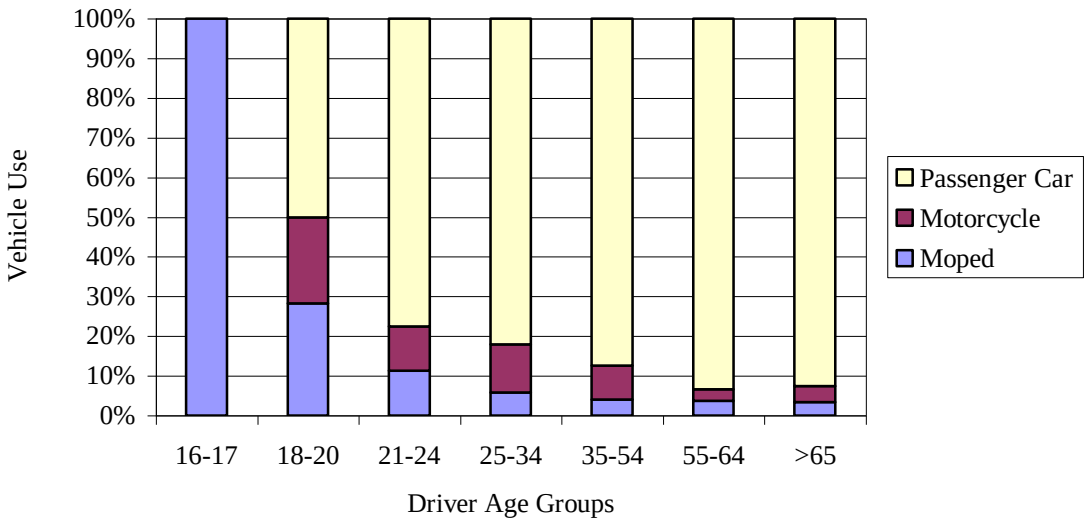

FIGURE 1. Passenger Car, Motorcycle and Moped Usage in Relation to Driver Age

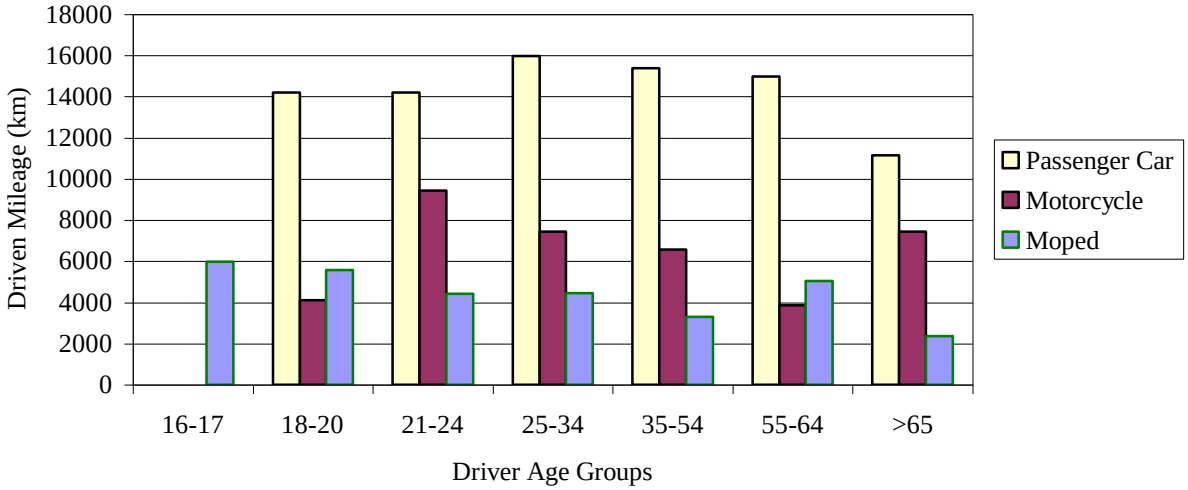

FIGURE 2. Mileage Driven (km) in Relation to Driver Age

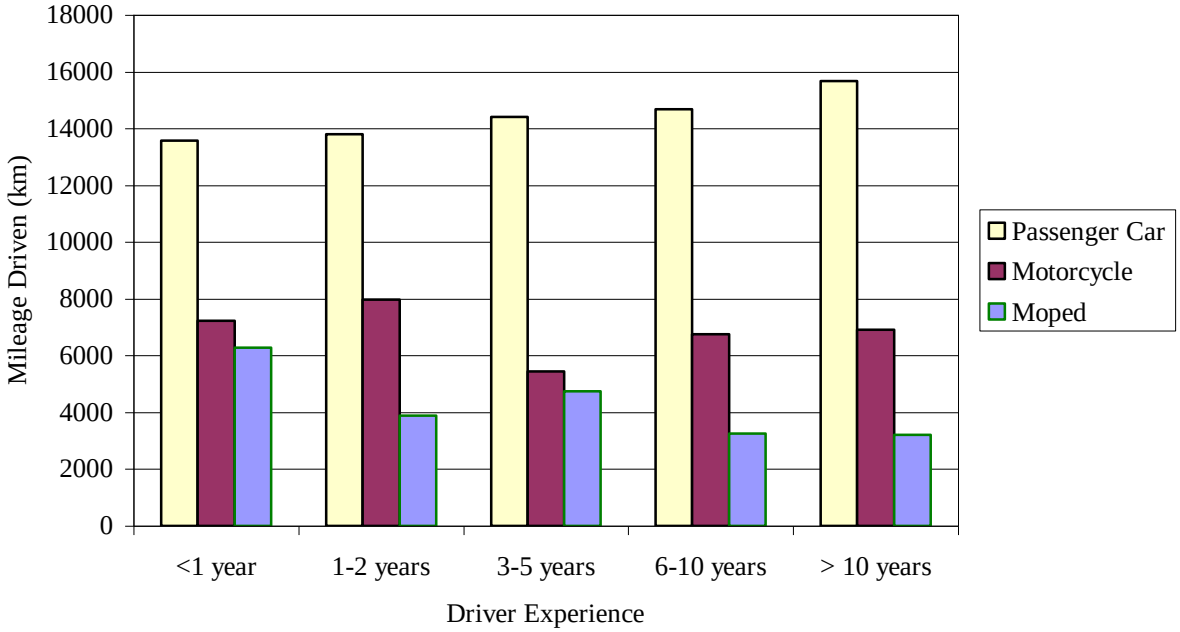

FIGURE 3. Mileage Driven (km) in Relation to Driver Experience