MOTORCYCLE OWNERSHIP: A TIME-SERIES INVESTIGATION

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ABSTRACT

In this paper we discuss modeling issues in the context of motorcycle ownership using a 12-year monthly time series dataset from Athens, Greece. The models developed provide information on variable elasticities that affect ownership, a topic that has not been investigated in the literature. Results suggest that motorcycle ownership largely depends on socioeconomic factors and fuel price variations; for example, increases in personal per capita income and fuel prices increase motorcycle ownership, while unemployment increase may be connected to increased motorcycle ownership as well.

Keywords: Motorcycle Ownership, Transport Economics

1. INTRODUCTION

Much research has been conducted in the past few years in the area of motorcycle safety; in general, motorcyclists are more likely to be involved in road accidents compared to motorists (CARE - Community database on Accidents on the Roads in Europe, August 2008). In addition, the severity of the accidents in which motorcycles have been involved is much higher than those of other vehicle categories (Australian Transport Safety Bureau, 2003). Motorcycles have higher fatality rates per unit of distance travelled in comparison to automobiles (National Highway Traffic Safety Administration, 2006); according to the National Highway Traffic Safety Administration (NHTSA), in 2006 18.06 cars out of 100,000 were involved in fatal crashes, while the corresponding rate for motorcycles was 55.82. This high accident rate is coupled with large ownership numbers such as over seven million motorcycles registered in the US and thirty million in Europe (United States Department of Transportation - Federal Highway Administration, 2006, European Commission, 2009). According to the European Road Safety Observatory (2008), motorcycle fatalities represent

approximately 16% of all highway fatalities each year in Europe, while motorcycles represent just 3% of all registered vehicles and 0.4% of vehicle miles traveled (National Highway Traffic Safety Administration, 2006). Further, motorcycling is the only mode of transport with an increasing number of fatalities during the last decade (CARE - Community database on Accidents on the Roads in Europe, August 2008), and figures indicate that 25% of total motorcycle fatalities happen for individuals between 15 and 24 years of age (CARE Database / EC, August 2008). And, while researchers have covered many issues related to motorcycle safety and the factors that affect it, issues related to ownership and its influencing factors have not received adequate attention.

Motorcycle transport is an important mode of travel in many countries around the World, including Asia and Southern Europe; In Greece, for example, the number of motorcycles corresponds to a quarter of the number of automobiles. However, surprisingly little research has been undertaken in the area of modeling and predicting ownership and, as such, the goal of this paper is to study motorcycle ownership and uncover the factors that may have a significant effect on it.

2. DATA DESCRIPTION AND VARIABLES

In order to study the factors that affect motorcycle ownership, we employed a 12 year monthly dataset (January 1995 – December 2006) containing values for variables such as demographic, socio-economic and motorcycle ownership information. In the database developed, motorcycle ownership, unemployment levels, income and fuel prices are available, as well as the population of Athens.

Selection of the Dependent Variable

The data provide the exact number of motorcycles owned in Athens. The dependent variable (‘motorcycle ownership’) could be defined in several ways: i. as the absolute number of motorcycles, ii. as the difference of two consecutive monthly values or, iii. as the ratio of two consecutive monthly values. However, in order to consider the relationship between ownership and population, the dependent variable in the model is the ratio of motorcycles to the population of Athens, i.e. per capita motorcycle ownership.

Independent (Explanatory) Variables

The independent variables correspond to the demographic and socio-economic characteristics of the users. As previously mentioned, variables include unemployment (expressed as a percentage), fuel price, income and immigration information.

During the period discussed, significant changes were realised in the transport system of Athens. The most important development was the construction of two new metro lines. This should be considered as it could potentially change the process of choosing transportation

modes and, in turn, in the decision to purchase motorcycles. Metro operation was separated into four different phases, beginning in February of 2000; construction was finished in August of 2004. For each metro section, we introduce a binary independent variable (dummy); these variables have either the value '0' (metro section not in operation for the given month) or the value '1' (metro section in operation for the given month). In addition, we considered the possible effect of the Olympic Games by introducing an additional binary indicator with the value of '1' for the period of the Games (July, August and September 2004).

3. DESCRIPTIVE STATISTICS

We provide here descriptive statistics for the variables considered in the analysis (Table I).

Table I – Descriptive Statistics

VARIABLE	MEAN	STD. DEV.	MINIMUM	MAXIMUM
MOTOS PC	0.2251	0.0665	0.1212	0.3457
UNEMPLMNT	10.2771	1.0021	8.3000	12.7000
FUEL	110.5700	25.5300	68.5000	170.0000
INCOME	10,643.60	475.96	9,682.28	11,821.6
IMMIGRATION	187,822	25,544	152,834	219,669

The total number of motorcycles owned in Athens in January of 1995 was approximately 420,000, while within 12 years this value almost tripled (1,200,000 motorcycles in December of 2006). The population of Athens was relatively stable during the period discussed at a value of 3.5 million people. In the first figure (Figure 1), the trends for the population of Athens and for motorcycle ownership are shown. In Figure 2, a clear trend in per capita motorcycle ownership is clear.

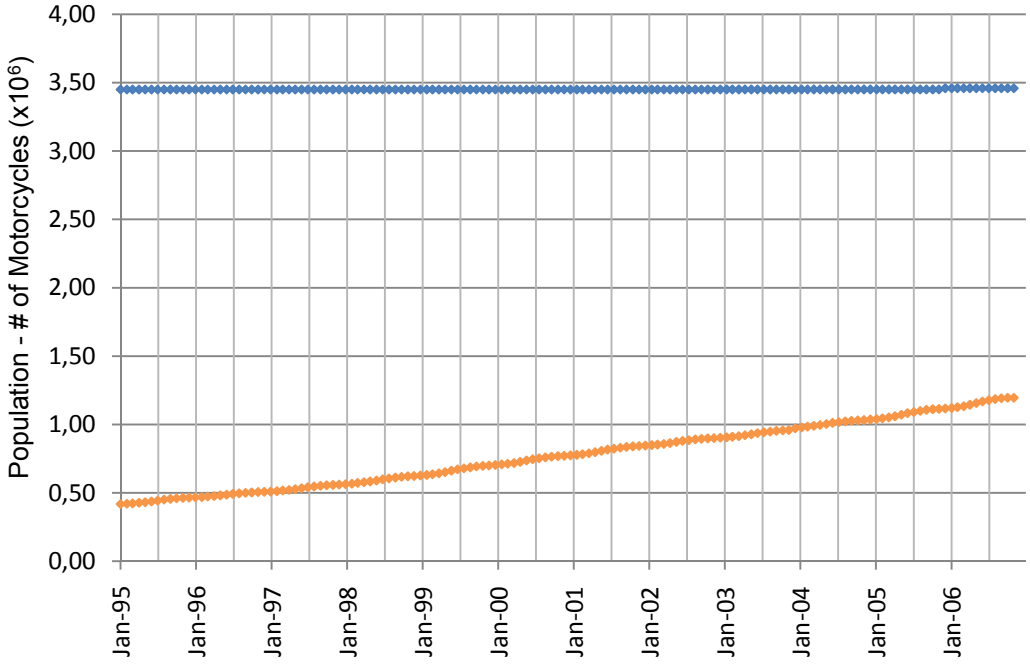

Figure 1 – Population and Motorcycle Ownership for Athens (1995 – 2006)

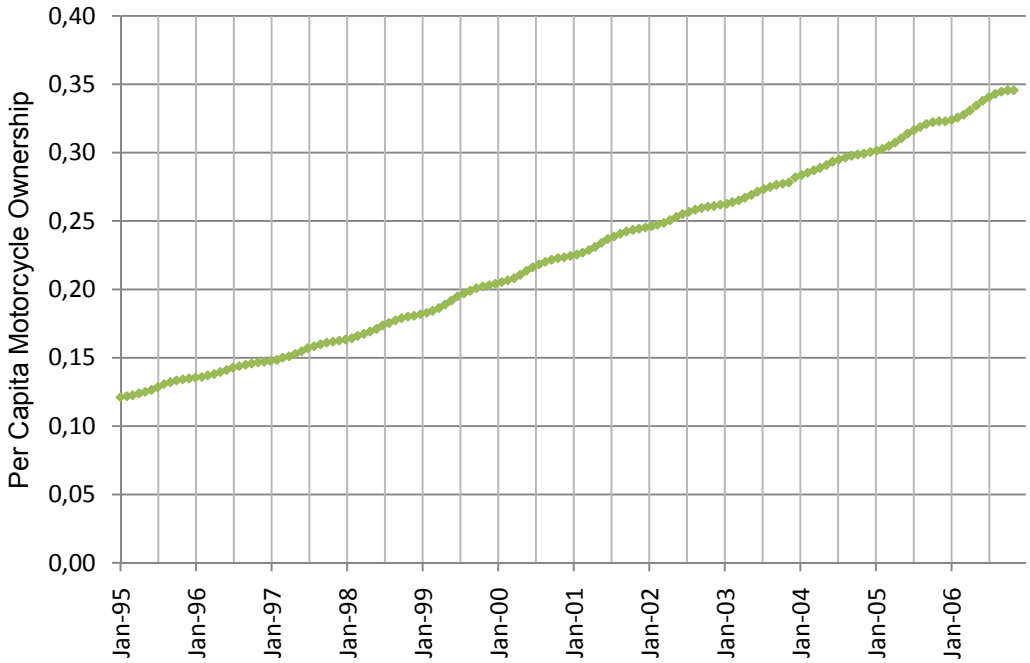

Figure 2 – Per Capita Motorcycle Ownership for Athens (1995 – 2006)

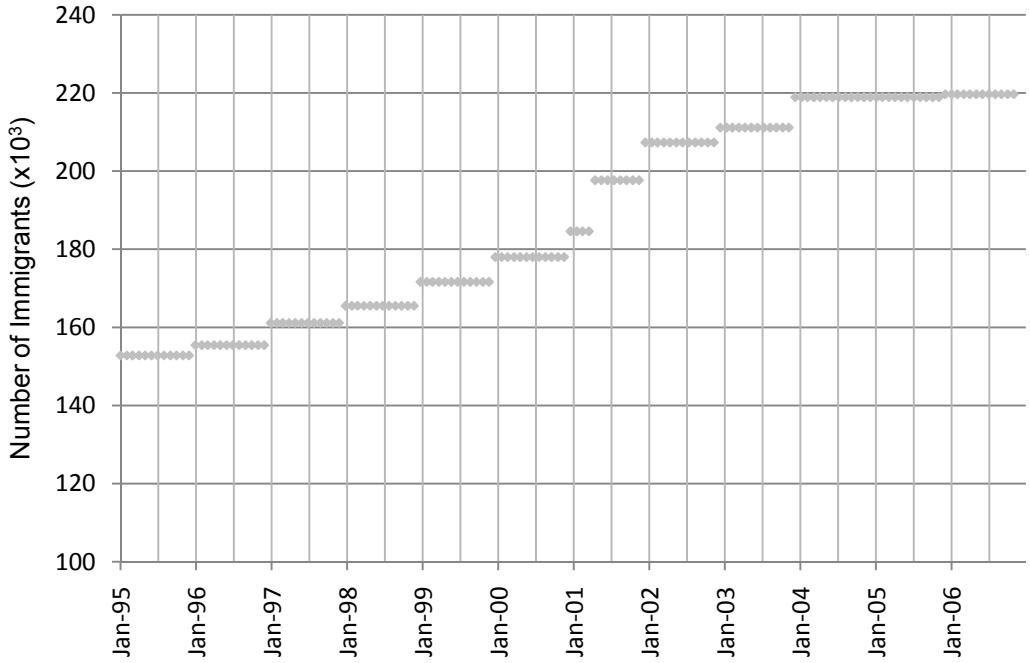

Figure 3 – Immigration for Athens (1995 – 2006)

The number of immigrants from January of 1995 to December of 2006 shows an increase of about 45% (Figure 3). As shown in Figures 5 and 6, unemployment and income have a highly fluctuating trend during the period investigated.

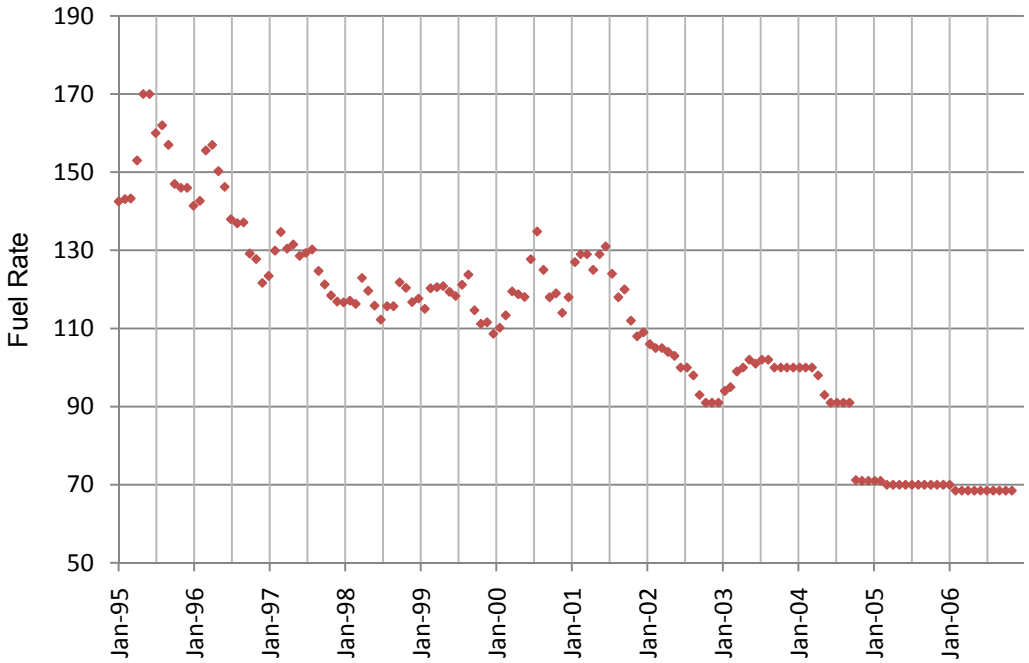

Figure 4 – Fuel Rate for Athens (1995 – 2006)

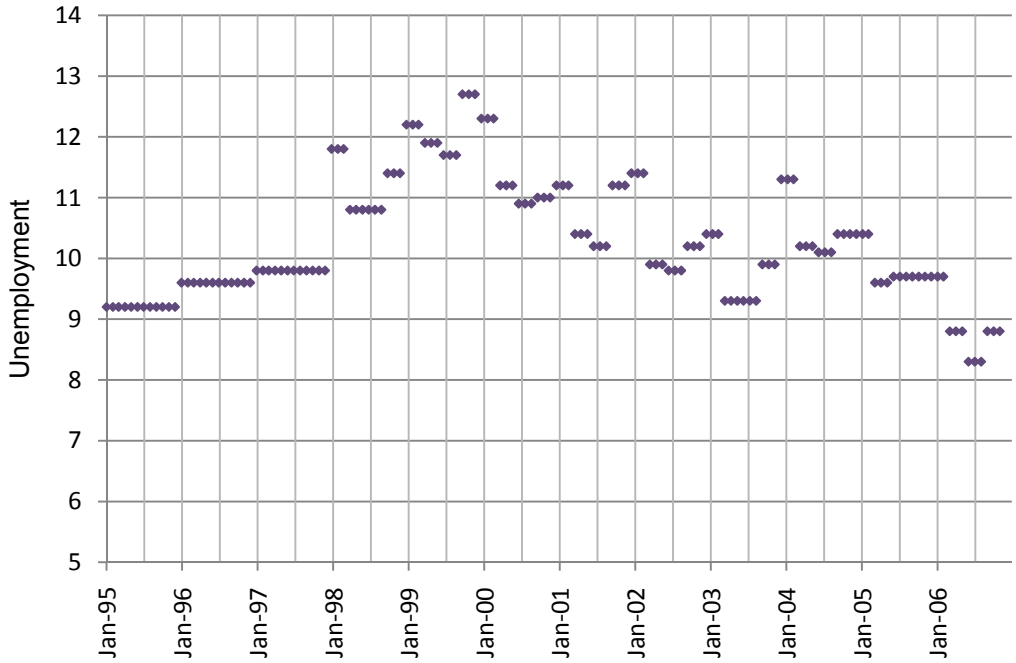

Figure 5 – Unemployment for Athens (1995 – 2006)

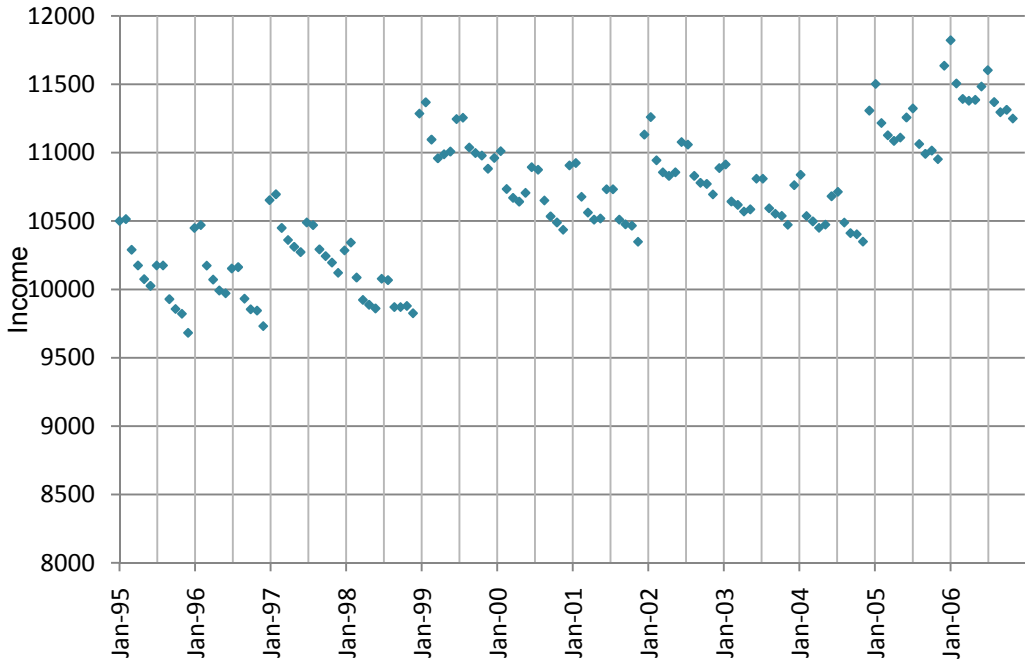

Figure 6 – Income for Athens (1995 – 2006)

In order to determine the variables to include in the model, we investigate the correlation between all variables. It is generally a good statistical practice, in order to avoid multicollinearity and inefficient parameter estimates (Washington et al., 2010), to choose explanatory variables that have a high correlation with the dependent variable, on one hand, but as low correlation as possible between them. Table II depicts the correlation between the available explanatory variables. The correlation coefficient takes on values from '-1' to '+1' (in this case we are not interested in the sign of the correlation. From the Table II it is obvious that per capita motorcycle ownership is described by fuel prices, income and immigration rates. Besides this, we should not include in the same model fuel and immigration as independent variables. Figures 7 – 12 depict the relationship between the dependent and independent variables as well as the pairwise correlation of the explanatory variables.

Table II – Correlation Matrix

	MOTOS PC	UNEMPLMNT	FUEL	INCOME	IMMIGRATION
MOTOS PC	1.00	-0.17	-0.93	0.70	0.97
UNEMPLMNT	-0.17	1.00	0.11	0.05	-0.16
FUEL	-0.93	0.11	1.00	-0.68	-0.88
INCOME	0.70	0.05	-0.68	1.00	0.66
IMMIGRATION	-0.97	-0.16	-0.88	0.66	1.00

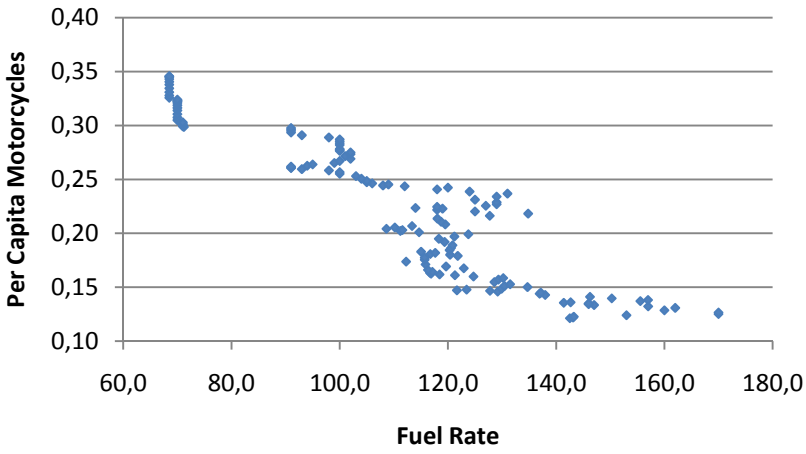

Figure 7 – Correlation between per capita motorcycle ownership and fuel rate

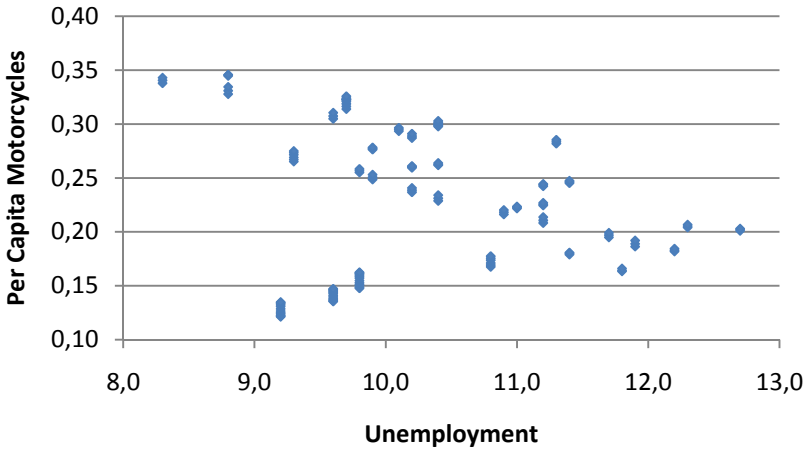

Figure 8 – Correlation between per capita motorcycle ownership and unemployment rate

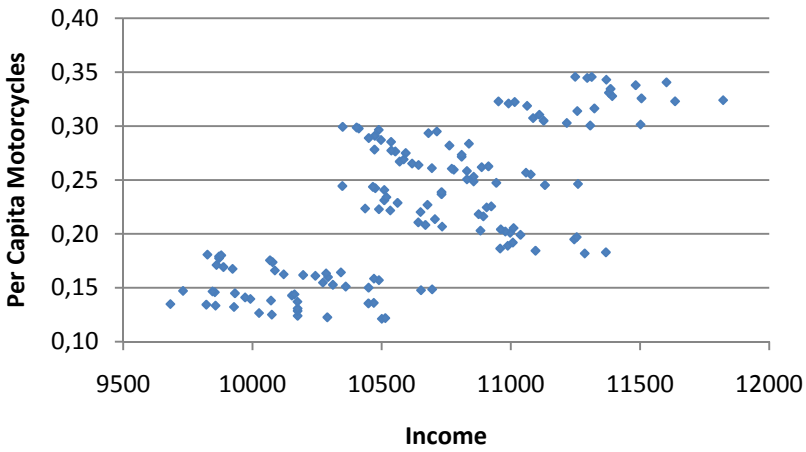

Figure 9 – Correlation between per capita motorcycle ownership and income rate

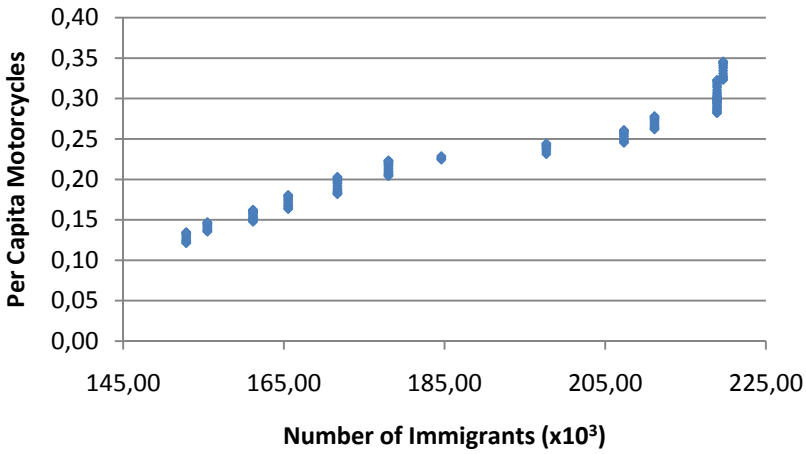

Figure 10 – Correlation between per capita motorcycle ownership and the number of immigrants

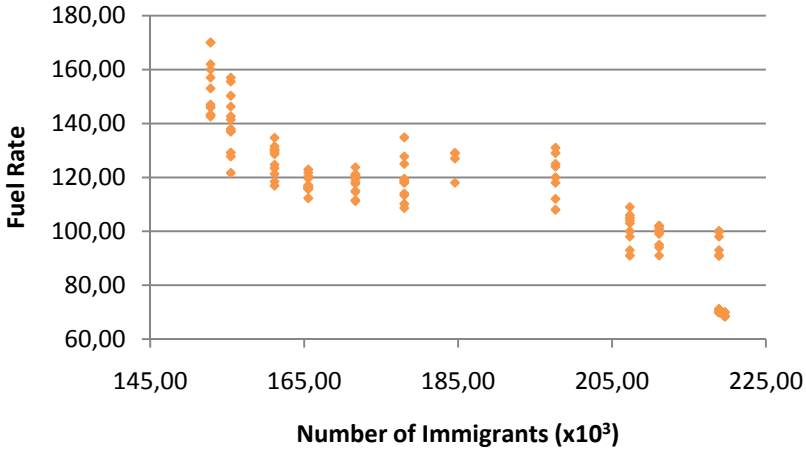

Figure 11 – Correlation between the number of immigrants and fuel rate (high correlation)

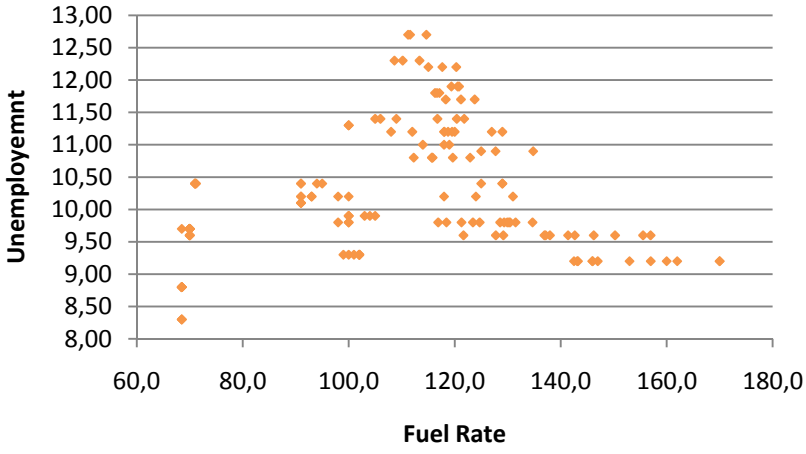

Figure 12 – Correlation between unemployment and fuel rate (low correlation)

4. THE MODEL

This section describes the mathematical framework and methodology for estimating the statistical model. The results of the statistic analysis are presented as well.

Approach

Considering the relationship between the independent ('per capita motorcycles') and the dependent variables as well as the variance of the motorcycle ownership, we employ a double-log linear regression model. Of the following typical form:

$$\log(y) = b_1 + b_2 \log(x_2) + \cdots + b_n \log(x_n) + e \ ,$$

where 'y' is the dependent variable, 'x_i' the independent variables, 'b_1' a constant, 'b_i' (i = 2, 3, …, n) are coefficient estimates for each independent variable and, 'e' is the error term.

The relationship that describes the curve cannot be estimated by the Ordinary Least Squared method, as in the simple linear regression. However, if we 'remove' the logarithm from both sides, the result is a relationship that the OLS method can describe. This method estimates the values of the parameters of the double-log model by minimizing the sum of the squared residuals:

$$min \sum_{i=1}^{n} (e_i)^2$$

This transformation is possible because all the values of the variables have a positive sign. While in this model the constant and the residual have the same interpretation, the parameters do not have an absolute value. Thus, in the simple linear model the parameter of the explanatory variable corresponds directly to the slope, while in the double-logarithmic linear model the parameter estimates refer to elasticities. In the simple linear model the elasticities vary depending on the data. On the contrary, the log-log model assumes a constant elasticity over the values of the data set. The definition of the point elasticity is:

$$\varepsilon = (\frac{\Delta y}{y})/(\frac{\Delta x}{x})$$

Estimating the double-log model, we have the following result:

$$b_i = \frac{\Delta \log(y)}{\Delta \log(x)} \sim \frac{\Delta y/y}{\Delta x/x} = \varepsilon$$

Results

The parameters of the model that 'best' describes the dependent variable appears in Table III. Our purpose is to choose explanatory variables that are statistically significant and have a rationally explainable sign. The dependent variables initially employed were the logarithms of unemployment, fuel price, income and immigration rates, as well as the year, month, season and metro dummies. In addition, we took into consideration the possible influence of the values of previous months (dynamic model).

Table III – Results of the Double-Log Linear Model

Independent Variables	*Linear Regression*		
	Coefficient Estimate	Standard Error	Approximate t-Statistic
Constant	-1.2212	0.025	-48.312
LUNEMPLMNT	0.1150	0.010	12.018
LFUEL	0.0901	0.011	8.524
TIME	0.0036	$0.2328E^{-4}$	156.684
SEASON1	-0.0067	0.0008	-8.203
SEASON2	-0.0035	0.0007	-4.449
METRO3	-0.0177	0.0014	-12.882
METRO4	-0.0094	0.0017	-5.646
Summary Statistics			
# of Observations	144		
R Squared	0,99		

In the table above we present the variables that are significant at the 95% confidence level. The sign of the coefficient determines the relationship between the dependent and the explanatory variable. Thus, we note that a rise of unemployment rate leads to an increase in the number of per capita motorcycles. Further, the relationship between the dependent variable and fuel prices is also positive, indicating that a rise in fuel prices causes a rise in the per capita motorcycle ownership, possibly as a result of a decrease in automobile ownership (to which motorcycles are an alternative). Interestingly, elasticity of fuel rate is 0,09, implying that for a 1% increase in the value of this variable, the motorcycle ownership increases by 0,09%, an indication that, at least in Athens, motorcycle ownership is highly inelastic with respect to fuel prices. The R^2 value of 0.99 is high, indicating a very good fit of the model to the available data.

5. CONCLUSIONS

The purpose of this study was to determine the factors that significantly influence motorcycle ownership. We developed a double-log regression model using time-series data. Model estimates suggest that increases in unemployment rate and fuel price cause an increase at motorcycle ownership. In cases of difficult economic conditions, it is expected that people turn to motorcycles instead of automobiles, as the required purchase cost and operational and maintenance cost are lower. Additionally, fuel prices increase the operational cost of the car and, consequently, more users turn to motorcycles. The demand for motorcycles is lower

during the first six months of every year, while the construction of two metro lines decreased the need for motorcycles as travelers increasingly turned to public transportation.

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