Estimating the Demand for Cigarettes in Greece: An Error Correction Model[*]

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Abstract

This paper provides an empirical analysis of cigarette consumption in Greece for the period 1960-1995 using the recent developments on cointegration techniques and error correction models. It was found that the empirical model performs well on both theoretical and statistical grounds. Short- and long-run impacts of price and income changes on cigarette demand were obtained and found to be small.

Keywords: *Cigarette consumption, cointegration, error correction model.*

Introduction

Several empirical studies have dealt with the demand for cigarettes; for a comprehensive review of these studies, see Cameron (1998). Among their common findings are: *first,* a statistically significant inelastic price response, which is much greater in the long-run. *Second,* the effect of health scares on cigarette consumption have been found to be negative and *third,* the corresponding effect of advertising was found to be of either sign and generally, inconclusive. Recently, however, questions have been raised about the consistency of the above results as most of previous studies using time-series data paid little or no attention on time-series properties of data used (Cameron, 1998). Empirical results referring to price and income elasticities, and/or the effects of health scares and advertising are highly questionable whenever based on spurious regressions.

For Greece, in particular, there are three empirical studies (i.e., Stavrinos, 1987; Zanias, 1987; Hondroyiannis and Papapetrou, 1997) analyzing cigarette demand. From these, only the study by Hondroyiannis and Papapetrou (1997) has taken into account the stochastic nature of the variables analyzed by considering the stationarity and cointegration of the related variables. Nevertheless, they have failed to incorporate straightforward theoretical properties (e.g. homogeneity in prices and income) on the estimated demand function, and they have also used nominal instead of real disposable income, which makes it difficult to interpret their results

The objective of this paper is to analyze empirically the demand for cigarettes in Greece during the period 1960-1995, by using a theoretically consistent model, which incorporates the property of linear homogeneity (i.e. there is no money illusion), on the estimated demand equation, and it also accounts for the stochastic nature of the variables analyzed. That is, the stationarity property of the variables used are firstly examined, then cointegration between variables is established and finally, an error correction model (ECM) is set up and estimated for the demand for cigarettes.

From this model, in which health scares and advertising effects are captured by dummy variables, estimates of short- and long-run price and income impacts on the cigarette consumption are obtained.

The present study is organized as follows. Section 2 discusses the theoretical model. The data and the empirical results are presented in Section 3. Finally, concluding remarks are given in Section 4.

The Theoretical Model

Boyd, 1991; Tansel, 1993; Valdes, 1993; Reekie, 1994; Hondroyiannis and Papapetrou, 1997), Following previous studies (e.g., Fujii, 1980; Stavrinos, 1987; Zanias, 1987; Seldon and we assume that the demand function for cigarettes is expressed as follows:

$$Q_t = f(P_t^c, P_t^o, Y_t, A_t, S_t) \qquad (1)$$

where Q_t is the quantity consumed of cigarettes per adult[1] in period t, P_t^c is the price of cigarettes (including taxes)[2], Y_t is the per capita disposable income[3], P_t^o the price of other consumer goods, A_t is the advertising expenditures and S_t is a vector of other factors such as the existence of legislation restricting smoking in public places, information provision on the risks of cigarette smoking, etc.

Assuming, in line with economic theory, that the demand function is homogenous of degree zero in prices and income, we have:

$$Q_t = f\left(\frac{P_t^c}{P_t^o}, \frac{Y_t}{P_t^o}, A_t, S_t\right) \qquad (2)$$

Our long-run and short-run analysis is based on the above demand function. The price of cigarettes in Greece is determined exogenously, typically by Greek legislation. Thus, the estimation of the demand function does not present identification problems.

Empirical Methodology, Data and Empirical Results

Before specifying the most appropriate dynamic form of Equation 2, it is necessary to investigate the time-series properties of data used in order to be able

to assess formally whether the long-run relation is economically meaningful or merely spurious (Harris, 1995). Initially, the number of unit roots should be identified for each individual time-series (i.e. the order of integration). In the case where both Q_t and the vector of explanatory variables are integrated of the same order, cointegration can be established for the demand equation. Then, an ECM is set up and estimated using OLS procedure.

The data used in the empirical analysis are annual and covers the period 1960-1995. Q_t is measured as the annual consumption of cigarettes per person over 15 years old. The evolution of cigarette consumption per adult is depicted in Figure 1. Cigarette consumption increased throughout the period 1960-1995, but at a lower rate of growth since 1979 when the anti-smoking campaign started.

Figure 1. Evolution of per Adult Cigarette Consumption Index in Greece, 1960-1995.
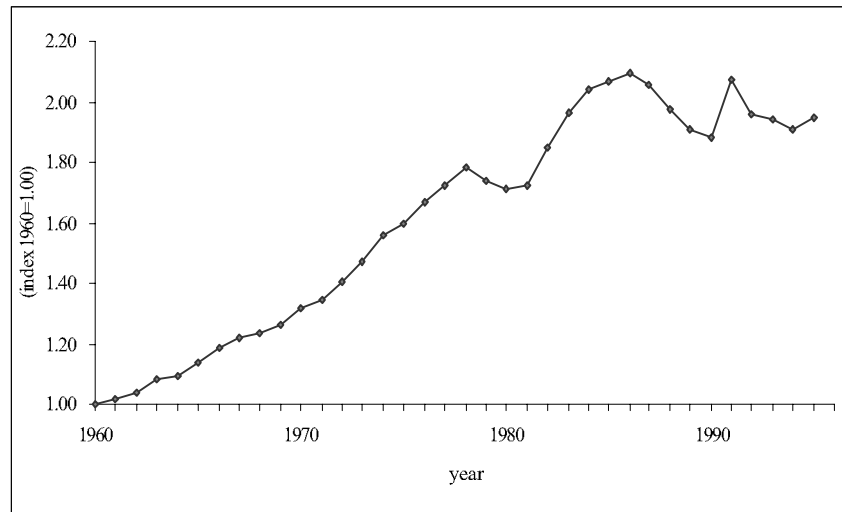
Source: Ministry of Finance and Greek Tobacco Industry Association.

Quantity data covering the period 1960-1990 are from the Ministry of Finance and those for the rest of the period under consideration are from the Greek Tobacco Industry Association. P_t^c is the cigarette price index (1970 = 100) and P_t^o is measured by the consumer price index (1970 = 100) excluding tobacco[4]. These data come from various issues of the Statistical Yearbook of Greece. Y_t is the undeflated per capita disposable income, obtained from various issues of National Accounts of Greece. All variables used in the analysis are in logarithmic form.

Also, in the absence of data on cigarette advertising expenditure, the dummy D_1 was used to capture the effect of cigarette advertising through television, which started in 1970 and stopped with the anti-smoking campaign of 1979. The dummy D_2 is used to capture the effect of the information provision and health

warning during the anti-smoking campaign years from 1979 to 1982. Finally, D_3 is a dummy for the effect of health warning on packages and other anti-smoking efforts during the period 1987-1995.

The results related to the time-series properties of these data are reported in Table 1. Based on Dickey-Fuller (DF) and augmented Dickey-Fuller (ADF) tests (Dickey and Fuller, 1981), the hypothesis that the variables $\ln Q_t$, $\ln\left(\dfrac{P^c}{P^o}\right)_t$ and

$\ln\left(\dfrac{Y}{P^o}\right)_t$ contain a unit root cannot be rejected at 5% significance level. When

first differences are used, unit root non-stationarity was rejected at the same level of significance. This indicates that the levels of all variables concerned are non-stationary processes, i.e. I(1), and thus, standard statistical inference is validated (Dickey and Fuller, 1981). Therefore, a possible presence of a long-run relationship must be investigated through cointegration techniques.

The cointegration vector is based on a vector autoregression (VAR) model. The number of lags was determined via the Sims (1980) likelihood ratio (LR) test corrected for the degrees of freedom. The LR test statistic selected a 3-lag VAR. The estimation of the cointegration equation was obtained by using the methodology developed by Johansen and Juselius (1990), who utilized a maximum likelihood procedure that jointly estimates the number of cointegrating vectors.

Table 1. Dickey-Fuller and Augmented Dickey-Fuller Unit Root Tests.

Variable (*x*)	Level		First difference	
	DF	**ADF**	**DF**	**ADF**
ln Q	-0.38285	-0.63127 (1)	-5.0783	-3.7883 (1)
ln (P^c/P^o)	-1.4891	-2.0345 (1)	-4.6668	-3.6562 (1)
ln (Y/P^o)	-1.3428	-1.3206 (1)	-5.1095	-4.3942 (1)

Notes: (a) The test for stationarity in the levels of variables is given by

$$\Delta x_t = \alpha + \beta Time + \gamma x_{t-1} + \sum_{j=1}^{s}\delta_j \Delta x_{t-j} + v_t.$$

When s = 0, the Dickey-Fuller test is obtained. The case s ≠ 0 defines the augmented Dickey-Fuller test. The null hypothesis that x_t is a non-stationary series is rejected if the coefficient γ is significantly negative, (b) The critical values for DF and ADF tests at 5% are -3.55 and -3.56 respectively, (c) The numbers in parentheses indicate the number of lags in ADF.

The results from the cointegration tests are presented in Table 2. According to these results, both the maximum eigenvalue test and the trace test statistics imply that there is one cointegrating vector among cigarette consumption, price

and disposable income. The existence of cointegration was also tested by using Phillips and Hansen (1990) methodology[5]. The corresponding statistic was –3.75, which is statistically significant at 10%.

The estimated long-run relationship is:

$$\ln Q_t = 6.397 - 0.4826 \ln\left(\frac{P^c}{P^o}\right)_t + 0.3993 \ln\left(\frac{Y}{P^o}\right)_t \tag{3}$$

Having established the presence of a cointegrating relationship between annual consumption of cigarettes per person over 15 years old, prices and per capita disposable income, the associated EC mechanism, which describes the short-run dynamics, is employed.

Table 2. Johansen-Juselius Maximum Likelihood Test for Cointegration.

Maximum lag in VAR=3			
List of eigenvalues in descending order:			
0.52653 0.32374 0.16988 0.0000			
Null	**Alternative**	**Statistic**	**95% critical value**
Maximum eingenvalues			
r = 0	r = 1	24.6729	22.0400
r ≤ 1	r = 2	12.9088	15.8700
r ≤ 2	r = 3	6.1442	9.1600
Trace statistic			
r = 0	r ≥ 1	43.7259	34.8700
r ≤ 1	r ≥ 2	19.0530	20.1800
r ≤ 2	r = 3	6.1442	9.1600

Note: r indicates the number of cointegrating relationships.

The EC mechanism has the following form:

$$\Delta \ln Q_t = \beta_0 + \sum_{i=1}^{2} \beta_{1i} \Delta \ln Q_{t-i} + \sum_{i=0}^{2} \beta_{2i} \Delta \ln\left(\frac{P^c}{P^o}\right)_{t-i} +$$

$$+ \sum_{i=0}^{2} \beta_{3i} \Delta \ln\left(\frac{Y}{P^o}\right)_{t-i} + \sum_{i=1}^{3} \delta_i D_{it} + \lambda \mu_{t-1} + u_i \tag{4}$$

where Δ refers to difference operator, μ_{t-1} are the estimated residuals from the cointegrating regression with λ being negative and u_t being a random term.

The estimation procedure yielded the following parsimonious EC model:

$$\Delta \ln Q_t = 0.28 \Delta \ln Q_{t-1} - 0.238 \Delta \ln\left(\frac{P^c}{P^o}\right)_t + 0.191 \ \Delta \ln\left(\frac{Y}{P^o}\right)_t - 0.042 D_3 - 0.33 u_{t-1} \qquad (5)$$

$$(2.09) \qquad (-3.54) \qquad\qquad (2.30) \qquad\quad (-2.83) \quad (-3.60)$$

$R^2 = 0.48$ $F(5, 29) = 7.75[0.00]$ $\log (LF) = 77.23$ $F_R(8, 20) = 0.67[0.68]$
$LM = 0.256[0.63]$ $RESET = 0.408[0.52]$ $NO = 0.208[0.91]$ $HE = 0.26[0.62]$

Numbers in parentheses denote t-statistics, while those in brackets denote p-values. F_R is an F-test of restrictions for going from the general ECM to Equation 5 and supports the reduction.

The error correction term in Equation 5 has the correct sign and it is significant, indicating that quantity demanded of cigarettes adjusts to restored long-run equilibrium after a short-run disturbance. The estimated equation satisfies certain econometric criteria, namely absence of serial correlation (LM), absence of functional misspecification (RESET), presence of normality (NO) and absence of heteroscedasticity (HE). The adjustment of cigarette consumption to the error correction term was found to be fairly rapid; one third of the adjustment is completed within one year or alternatively full adjustment will be completed in three years.

The estimated short-run dynamic impacts[6] of the price and income on the cigarette consumption are –0.24 and 0.19 respectively. On the other hand, the long-run price and income elasticities, which are given by the parameter estimates of the cointegrating regression, were estimated to be –0.48 and 0.40 respectively. The rather low price impact indicates that price increases will not be a very effective anti-smoking policy. On the other hand, an increase in taxes on cigarettes will increase the tax revenues of the government. In addition, the small effect of income on cigarette consumption indicates that smokers do not usually respond to higher incomes with higher levels of cigarette consumption, but rather with a shift to more expensive brands.

It should be noted, that the price and income impacts presented here are lower than those of Hondroyiannis and Papapetrou (1977). Given the similarity in econometric estimation with Hondroyiannis and Papapetrou, the lower values of price and income impacts are most probably due to the imposition of linear homogeneity.

With respect to dummy variables, only D_3 has a statistically significant and negative effect on cigarette consumption. According to our findings, health warning on packages and other anti-smoking efforts have resulted in a 4.2% decrease in the annual growth rate of cigarette consumption during the period 1987-1990. On the other hand, advertising had a positive but insignificant effect on cigarette consumption. This may be explained by the fact that advertising tends to encourage brand switching rather than to increase the total level of market demand (Hamilton, 1972; Reekie, 1994; Cameron, 1998). Also, the 1979-1982 anti-smoking campaign had a negative but statistically insignificant effect on cigarette demand[7].

Concluding Remarks

This paper examines the characteristics of cigarette demand in Greece using the recent developments on cointegration techniques and error correction models for the period 1960-1995. It was found that the empirical model performs well on both theoretical and statistical grounds.

As expected, demand is a negative function of price and a positive function of income. The short- and long-run price and income impacts on cigarette consumption were found to be small. The rather low price impact on demand indicates that, by themselves, price (tax) increases will not be a very effective anti-smoking policy. It may also be true that although price increases may not affect significantly the total amount of cigarettes, the decision to start smoking is quite influenced.

The empirical results suggest that health warnings about adverse health effects of smoking may be more effective in reducing consumption than raising the price of cigarettes.

Notes

1. The relevant smoking population is defined as people over 15 years old.
2. This is more appropriate than a whole sale price index that excludes taxes (Seldon and Boyd, 1991).
3. Per capita disposable income is based on the entire population in order to reflect the fact that all individuals hold claims on disposable income (Tansel, 1993).
4. The use of the conventional consumer price index, which also includes tobacco, did not alter our econometric results, as tobacco's share on consumers' basket is very small. Consequently, the use of P_t^o does not cause any bias in the estimated parameters (Tansel, 1993; Valdes, 1993).
5. Phillips and Hansen (1990) proposed a fully modified OLS estimator to remove some bias in OLS estimation of the cointegrating vector. A simple exposition of this methodology is given in Evans and Lewis (1992).
6. Many authors interpret the coefficients of the price and income difference terms of the ECM as short-run price and income elasticities (see Johnson, *et. al.*, 1992, Hallam and Zanoli, 1993, Hondroyiannis and Papapetrou, 1977 and Mergos and Stoforos, 1997).
7. The estimated coefficient of D_1 is 0.004 with a t-statistic of 0.30 and that of D_2 are -0.010 and -0.62, respectively.

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