

Forecasting Cigarette Consumption in Greece: An empirical investigation with cointegration analysis

Nikolaos Dritsakis*

Abstract

This paper investigates the relationship between cigarette consumption per capita net disposable income, cigarette price index, and per capita expenditure for education. In this empirical analysis the Johansen cointegration test is applied in conjunction with the vector error correction model. Finally, the forecasting technique of cigarettes consumption in Greece using cointegration models is presented as well. This technique presupposes the formation of a structural equations system, which includes the short-run and the long-run relationships of the model variables.

Key words: *cigarette consumption, cointegration, error correction model, forecasting technique*

Introduction

Until some years ago, there wasn't any information available on the quality of life of those who smoke and those who are passive smokers in Greece. Then an effort was made to inform the public about the health implications of smoking. The first organized anti-smoking policies were deployed during the period 1979-1982, and have continued ever since with the scope to emphasize the consequences of smoking in public health. The minister of health and welfare banned smoking in public areas, in means of transportation and in units providing health services, according to a recent law introduced in August 2002 (Government Newspaper Brochure 1001). On the other hand we do not have information on the costs of smoking and the taxes that government levies by cigarette consumption. The revised common agricultural policy (CAP), which has been applied by the European Union member countries, was based on the 2025/92 regulation which defined three basic principles: Firstly, the regime of bounty, secondly the testing system of production, and final the production direction. This policy induced intense problems to the Greek economy, since for the first time a clearly national product like tobacco faced so many problems, given the fact that lands of moderate fertility are made productive by the tobacco production, unemployment is reduced, and tobacco itself represents an important product of exported trade.

* Associate Professor, University of Macedonia, Economics and Social Sciences, Department of Applied Informatics, 156 Egnatia Street, P.O box 1591, 540 06 Thessaloniki, Greece
FAX: (2310) 891290, e-mail: drits@uom.gr

There is a large enough amount of empirical researches that have been made regarding cigarette consumption in Greece and in other countries. Indicatively, we report the papers by Hamilton (1972), Fujii (1980), Tansel (1993), Valdes (1993), Cameron (1998), who have investigated the negative effects of smoking in public health, such as the effects of different anti-smoking advertising campaigns and their effectiveness in the restriction of cigarette consumption. Since, there have been joined efforts by most governments to emphasize the harmful effects of smoking, it appears that the public is more informed about the relation of smoking with other serious and many times deadly diseases. On the other hand, cigarette consumption plays an important role in the public economic policy of each government, since both cigarette and beverages consumption form one of the major sources of tax revenues. The paper by Seldon and Boyd (1991) for Great Britain showed that cigarette consumption increases with industrial advertising, while it decreases with government intervention against smoking but by a much smaller percentage than that of the industrial advertising of cigarettes. The paper by Reekie (1994) for South America indicated that cigarette demand is defined by the price and the disposable income more than the expenditure for advertisement, while the paper by Reinhardt and Giles (2001) for Canada reached adverse conclusions and supported that cigarette demand is extremely indifferent to the changes of income and prices. In the Greek literature, the papers by Stavrinou (1987) and Zania (1987) reported that the anti-smoking advertising campaign that the government followed in the period 1979-1981 was based more on anti-smoking propaganda than on tax revenues that derived from the cigarette consumption. Then, the debate that had been developed for the effectiveness of advertising campaign coupled with the importance of tobacco in the Greek economy, led to the abandonment of this campaign in 1981. The papers by Hondroyannis and Papapetrou (1997), Nikolaou and Velentzas (2001), provide an empirical analysis of cigarette consumption using income elasticities for the short-run and the long-run period.

In our empirical analysis we use apart from cointegration analysis and error correction model, the forecasting technique through the framework of forecasting technique into the sample (Ex-Post), which is based on the second Chow test, and out of sample (Ex-ante) adopting the Gauss-Seidel estimation strategy by the formation of a structural equations system that includes the short-run and the long-run relationships of the model variables.

The remainder of this paper proceeds as follows: Section II analyses the data that are used in cigarette consumption analysis in Greece. Section III estimates the results of unit roots test. Section IV summarises the cointegration analysis and the Johansen test for cointegration. Section V describes the error correction models. Section VI presents the prediction results of cigarettes consumption. Finally, section VII provides some last conclusive notes.

Data

For the cigarettes consumption analysis in Greece the following function is used:

$$QD = f(YD, RP, ED) \quad (1)$$

where QD expresses cigarette consumption per person over 15 years, YD is the per capita net disposable income, RP is the cigarette price index and ED is the per capita expenditures for education. The effects of per capita expenditures for education on cigarettes demand are hypothesized to be through two channels. On the one hand higher educational attainments mean higher incomes and, as a result increased cigarettes demand. On the other hand, the better educated can be expected to be more informed about the adverse health effects of smoking, and this fact implies a factor of decreasing cigarettes demand. All variables are reported in million drachmas and constant prices, regarding 1970 as a base year. The examination period is from 1960 to 2000. All data are expressed in logarithms in order to include the proliferative effect of time series and are symbolized with the letter L preceding each variable name. The data sources are the National Statistical Service of Greece, National Accounts of Greece, and Bank of Greece.

The list of variables that have been used in cigarette consumption analysis for Greece is the following:

LQD = Logarithm of cigarette consumption per person over 15 years.

LYD = Logarithm of per capita net disposable income.

LRP = Logarithm of cigarette prices index.

LED = Logarithm of per capita expenditures for education.

If these variables share a common stochastic trend and their first differences are stationary, then they can be cointegrated. Economic theory scarcely provides some guidance for which variables appear to have a stochastic trend and when these trends are common among the examined variables as well. For the analysis of the multivariate time series that include stochastic trends, the augmented Dickey-Fuller unit root test is used for the estimation of individual time series, with intention to provide evidence for when the variables are integrated. The unit root test is followed by the multivariate cointegration analysis.

Unit root test

The cointegration test among the variables that are used in the above model requires previously the test for the existence of unit root for each variable and especially, for the cigarette consumption per person over 15 years, the cigarette price index, the per capita net disposable income and the per capita expenditures for education, using the augmented Dickey-Fuller (ADF) (1979) test on the following regression:

$$\Delta X_t = \delta_0 + \delta_1 t + \delta_2 X_{t-1} + \sum_{i=1}^k \alpha_i \Delta X_{t-i} + u_t \quad (2)$$

The ADF regression tests for the existence of unit root of X_t , namely in the logarithm of all model variables at time t . The variable ΔX_{t-1} expresses the first differences with k lags and final u_t is the variable that adjusts the errors of autocorrelation. The coefficients δ_0 , δ_1 , δ_2 , and α_i are being estimated. The null and the alternative hypothesis for the existence of unit root in variable X_t is

$$H_0 : \delta_2 = 0 \quad H_e : \delta_2 < 0$$

The results of these tests appear in Table 1. The minimum values of the Akaike (AIC) and Schwartz (SC) statistics have provided the better structure of the ADF equations as well as the relative numbers of time lags, under the indication "Lag". As far as the autocorrelation disturbance term test is concerned, the Lagrange Multiplier LM(1) test has been used. The MFIT 4.0 (1997) econometric package that was used for the estimation of ADF test, provides us the simulated critical values.

Table 1. DF/ADF unit root tests

<i>Variables</i> (X_t)	<i>In levels</i>			<i>1st differences</i>		
	<i>Lag</i>	<i>Test statistic</i> (DF/ADF)*	<i>LM(1)**</i>	<i>Lag</i>	<i>Test statistic</i> (DF/ADF)*	<i>LM(1)**</i>
LQD	2	-1.4057	3.3171 [0.069]	1	-7.1695	0.1203 [0.729]
LYD	1	-1.4178	0.0792 [0.778]	1	-6.8609	3.2997 [0.121]
LRP	2	-2.2857	0.2102 [0.647]	1	-9.8941	0.1081 [0.742]
LED	2	-3.3698	0.0900 [0.764]	1	-6.6319	1.2091 [0.272]

* Critical value: - 3.5386

** The numbers in brackets show the levels of significance

The results of Table 1 suggest that the null hypothesis of a unit root in the time series cannot be rejected at a 5% level of significance in variable levels. Therefore, no time series appear to be stationary in variable levels. However, when the logarithms of the time series are transformed into their first differences, they become stationary and consequently the related variables can be characterized integrated order one, I(1). Moreover, for all variables the LM(1) test first differences shows that there is no correlation in the disturbance terms.

Cointegration and Johansen test

If the time series (variables) are non-stationary in their levels, they can be integrated with integration order 1, when their first differences are stationary. These variables can be cointegrated as well, if there are one or more linear combinations among the variables that are stationary. If these variables are being cointegrated, then there is a constant long-run linear relationship among them.

Since it has been determined that the variables under examination are integrated of order 1, the cointegration test is performed. The testing hypothesis is the null of non-cointegration against the alternative that is the existence of cointegration using the Johansen (1988) maximum likelihood procedure, Johansen and Juselius (1990, 1992). An autoregressive coefficient is used for the modelling of each variable (that is regarded as endogenous) as a function of all lagged endogenous variables of the model. The Johansen cointegration analysis presupposes the estimation of the following relationship:

$$X_t = \mu + \Gamma_1 \Delta X_{t-1} + \Gamma_2 \Delta X_{t-2} + \dots + \Pi X_{t-k} + \varepsilon_t \tag{3}$$

where: X_t is a 4X1 vector containing the variables LQD, LYD, LRP, LRP.

Γ_i ($i=1,2,\dots,k-1$) is the 4X4 matrix of coefficients

Π is the 4X4 matrix of coefficients

μ is the 4X1 vector of constant terms

ε_t is the 4X1 vector of the disturbance terms coefficients

Given the fact that in order to apply the Johansen technique a sufficient number of time lags is required, we have followed the relative procedure, which is based on the calculation LR (Likelihood Ratio) test statistic (Sims, 1980). The results showed that the value $\rho=3$ is the appropriate specification for the above relationship. Further on we determine the cointegration vectors of the model, under the condition that matrix Π has an order $r < n$ ($n=4$). The procedure of calculating order r is related to the estimation of the characteristic roots (eigenvalues), which are the following:

$$\hat{\lambda}_1 = 0.49610 \quad \hat{\lambda}_2 = 0.42670 \quad \hat{\lambda}_3 = 0.27494 \quad \hat{\lambda}_4 = 0.00710$$

Table 2. Johansen and Juselius Cointegration Tests Variables LQD, LYD, LRP, LED, Maximum lag in VAR = 3

Eigenvalues			Critical Values	
Null	Alternative	Eigenvalue	95%	90%
$r = 0$	$r = 1$	26.0444	23.9200	21.5800
$r = 1$	$r = 2$	21.1411	17.6800	15.5700
$r = 2$	$r = 3$	10.2168	12.4300	11.2800
Trace Statistic			Critical Values	
Null	Alternative	Eigenvalue	95%	90%
$r = 0$	$r > 0$	59.4293	39.8100	36.6900
$r \leq 1$	$r > 1$	33.3849	24.0500	21.4600
$r \leq 2$	$r > 2$	10.2438	12.6600	11.2500

The results that appear in Table 2 suggest that the number of statistically significant cointegration vectors is equal to 2. On the basis of equation (3) and taking into account the data of the vector X_t , we came up with the following two long-run equilibrium relationships between the variables (t-ratio values are in parentheses):

$$\text{LQD} = 12.2029 - 0.32091\text{LYD} + 0.00181\text{LRP} - 0.39186\text{LED} \tag{a}$$

(10.334) (-1.7909) (2.1815) (-2.3918)

$$\text{LQD} = 40.6982 + 0.050430\text{LYD} - 0.00087\text{LRP} - 1.9421\text{LED} \tag{b}$$

(21.498) (2.1287) (-1.8701) (-1.9421)

According to the signs of the vector cointegration components and based on economic theory the relationship (b) can be used as an error correction mechanism in a VAR model.

The VAR model with a mechanism of error correction model

After determining that the logarithms of the model variables are cointegrated, we must estimate then a VAR model in which we shall include a mechanism of error correction model (MEC). The error-correction model arises from the long-run cointegration relationship and has the following form:

$$\Delta LQD_t = \text{lagged}(\Delta LQD_t, \Delta LYD_t, \Delta LRP_t, \Delta LED_t) + \lambda u_{t-1} + V_t \quad (3)$$

where Δ is reported to all variables first differences

u_{t-1} are the estimated residuals from the cointegrated regression (long-run relationship)

$-1 < \lambda < 0$ short-run parameter

V_t white noise disturbance term.

The final form of the Error-Correction Model was selected according to the approach suggested by Hendry, which is a "top-down" or "general to specific" approach (Maddala 1992). The initial order of time lag for the model is 2 years, because it is large enough to enclose the system's short-run dynamic. We also apply a number of diagnostic tests on the residuals of the model. We apply the Lagrange test (A) for the residuals' autocorrelation, the Heteroscedasticity test (D) and the Bera-Jarque (C) normality test. We also test the functional form of the model according to the Ramsey's Reset test. Chow's first and second tests check the model's predictive ability. Finally, CUSUM and CUSUMQ tests are performed. The Error-Correction Model appears in table 3.

We do not reject the estimations, which are based on the results of table 3 according to the statistical and diagnostic tests. The percentage of the total variation of the dependent variable that is described in our model is high enough (58%). The Error-Correction Term is statistically significant and has a negative sign, which confirms the long-run equilibrium relation between the independent and dependent variables. Additionally, its relative value 0,029 (-5,626) shows a satisfactory rate of convergence to the equilibrium state per period.

From the results of Table 3 we can see that a short-run increase of cigarette price index and per capita expenditure for education by 1%, induces a little cigarette consumption reduction by 0.07% and 0.08% respectively. Inversely, an increase of the per capita net disposable income by 1%, will induce an increase of cigarette consumption by 0.22%.

Table 3. Error-Correction Model

$\Delta L\hat{Q}D_t = 0,0235 + 0,58256\Delta LQD_{t-1} + 0,22713\Delta LYD_{t-1} - 0,0767\Delta LRP_{t-1} -$			
(4,265)	(1,815)	(2,750)	(-1,987)
[0,000]	[0,065]	[0,038]	[0,053]
$- 0,0820\Delta LED_{t-1} - 0,0297u_{t-1}$			
(-2,785)	(-5,626)		
[0,042]	[0,020]		
$\bar{R}^2 = 0,58$	F(5,25)=7,6414	DW=2,3497	
	[0,000]		

A: X ² [1] = 1,8690 [0,172]	B: X ² [1] = 0,0179 [0,893]
C: X ² [2] = 1,4626 [0,481]	D: X ² [1] = 0,8162 [0,366]
E: X ² [7] = 0,9989 [0,995]	F: X ² [6] = 1,0373 [0,984]

Δ: Denotes the first differences of the variables.

\bar{R}^2 = Coefficient of multiple determination adjusted for the degrees of freedom (d.f).

DW= Durbin-Watson statistic.

F(n, m)= F-statistic with n,m d.f respectively.

A: X²(n) Lagrange multiplier test of residual serial correlation, following x² distribution with n d.f.

B: X²(n) Ramsey’s Reset test for the functional form of the model, following x² distribution with n d.f.

C: X²(n) Normality test based on a test of skewness and kurtosis of residuals, following x² distribution with n d.f.

D: X²(n) Heteroscedasticity test, following x² distribution with n d.f.

E: X²(n) Chow’s second test for predictive failure, following x² distribution with n d.f.

F: X²(n) Chow’s first test of stability of the regression coefficients, following x² distribution with n d.f.

()= We denote the t-ratio for the corresponding estimated regression coefficient.

[]= We denote prob. Levels.

The forecasting of cigarettes consumption

For the model’s prediction ability and in the framework of forecasting technique into the sample (Ex-Post), the predictive failure test has been adopted, which is based on the second Chow test. For the predictions elution apart from those of the sample (Ex-ante), for three consecutive years, the Gauss – Seidel sequential estimation strategy was adopted, Sarantis and Steward (1995). The forecasting technique using cointegration error correction models presupposes the formation of a structural equations system,

which includes the short-run and the long-run relationships of examined variables. This structural system consists of the three following equations:

$$\Delta LQD_t = \beta_0 + \beta_1' \Delta Y_{t-1} + \beta_2 \Delta LQD_{t-1} - \beta_3 u_{t-1} \quad (1a)$$

$$LQD_t = LQD_{t-1} + \Delta LQD_t \quad (2a)$$

$$u_t = LQD_t - \alpha' Y_t \quad (3a)$$

where: Y : is the vector of explanatory variables in the respective structural model.
 u_{t-1} : is the lagged residuals from the corresponding cointegration relationship.

The first function represents an error correction model, the second function is used for the forecasting of cigarettes consumption and the third function is a cointegrated function with the residuals as dependent variables. Furthermore, we could note firstly that the price of cigarette consumption change for the year 2001 is predicted. Then this price is inserted in the equations system, and the re-estimation of equations is performed. The new parameters that have derived, are inserted to the system and are used for the prediction of the next period. Table 4 presents the predicted and current prices of cigarette consumption. From the results of Table 4 we infer that the model can make satisfactory predictions for the sample period (Ex-Post).

Table 4. Forecasting of cigarette consumption (Ex – Post)

Year	Current Prices	Forecast Prices	Estimation Error
1996	9.9619	10.1288	-0.16690
1997	9.9662	10.1706	-0.20438
1998	9.9758	10.2008	-0.22504
1999	9.9807	10.2379	-0.25724
2000	9.9832	10.2783	-0.29517

Predictive Failure test $F(5, 32) = 0.89423$ [0.497]

In Table 5 all statistical predictions criteria are presented. The low Theil's statistics criterion indicates that the model can make predictions quite satisfactorily. A very important matter is that the equation does not contain biased characteristics almost at all,

Table 5. Summary statistics for forecasts

Mean Prediction Errors	-0.027
Mean Sum of Absolute Prediction Errors	0.045
Theil inequality coefficient	0.143
Bias Proportion	0.000
Variance Proportion	0.043
Covariance Proportion	0.956
Sum of Squares of Prediction Errors	0.002
Root Mean Sum of Squares of Prediction Errors	0.051

namely it does not underestimate or overestimate the changes of cigarette consumption. The remainder prediction statistics criteria are able to fill the positive figure of the model in its ability to predict.

From the results of table 4 and table 5 we infer that the model can make predictions quite satisfactorily into the sample period (Ex-Post). Table 6 presents the cigarettes consumption predictions for the period 2001-2003 (Ex-ante). The positive impressions of the above prediction form an extension of the good predictions of the model in forecasting cigarette consumption by the formulation of a structural system equations containing the long-run and the short-run relationships of the examined variables.

Table 6. Forecasts 2001 – 2003 (Ex – ante)

	2001	2002	2003
Δ LQD	0.069	0.145	0.026
LQD	10.2814	10.2998	10.3052
% Change	0.03	0.37	0.05

Conclusions

The present paper examines the characteristics of cigarette consumption in Greece using annual data for the period 1960-2000. This empirical analysis indicated that the variables, which determine the cigarette consumption in Greece satisfy the hypothesis of the unit root existence. On this basis, the cointegration analysis has been used as suggested by Johansen and Juselius in order to derive a long-run equilibrium relationship among cigarette consumption, cigarette price index per capita net disposable income and per capita expenditures for education. The results suggest that there is a negative relationship among cigarette consumption, cigarette price index and per capita expenditures for education, while there is a positive relationship between cigarettes consumption and per capita net disposable income. The results of this paper suggested that the effect of the per capita expenditures for education may be more effective in reducing consumption than raising the prices of cigarettes.

Then the methodology of error correction model was applied and the short-run and the long-run relationships were estimated. The selected vectors provided us error correction terms, which proved to be very important for their insertion to the long-run dynamic equations. Given the predictive ability of a structural equations system containing the short-run and the long-run relationships of the model variables predictions elution of cigarettes consumption can be performed for the next years. Finally, the results of the forecasting technique suggested that there was an increase in cigarette consumption for 2001 and 2002 years, while we noted lower percentage rate increase in 2003 than 2002, possibly due to the ban of smoking in public places.

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