ΣΠΟΥΔΑΙ», Τόμος 55, Τεύχος 3ο, (2005) / «SPOUDAI», Vol. 55, No 3, (2005), University of Piraeus, pp. 34-54

TAXES AND ECONOMIC INDICATORS: AN EMPIRICAL INVESTIGATION FOR GREECE

By

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Abstract

This paper examines the relationship between tax revenues and three economic indicators, change in gross domestic product, savings and investment as a percentage of GDP, using annual data for the period 1965-2002. The purpose of the paper is to test the long-run relationship between tax variables and economic indicators using cointegration analysis suggested by Johansen and Juselious. Moreover, we applied the seemingly unrelated regression (SURE) approach in order to determine tax components. The results of this analysis present a long run relationship between economic indicators and tax revenue variables.

Keywords: Tax revenue, economic indicators, cointegration, seemingly unrelated regression (JEL: A10, H20).

1. Introduction

Taxation policy can be regarded as the necessary component of economic policies for every country in order to sustain and improve their competitiveness and growth internationally. Nowadays with the highly moving capital and specialized work, the tax structure should be competitive in order to attract capital, specialized work and technology which are essential elements for maximizing economic growth. Several studies have shown that the structure of taxation can have a major influence on the real sector and that taxation policy can therefore be an important tool for promoting saving, investment and economic growth.

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The authors are grateful to an anonymous referee for helpful comments and useful suggestions.

However, theoretical literature suggests that increased taxation and public spending is likely to have been an important contributory factor to the fall in private savings because it reduced both the incentive to save and the income stream from which savings are generated. Many empirical issues with respect to the determination of private savings are still open: the burden of taxation rose, private savings declined but the mechanism by which this happened is not entirely clear. This bridge between theory and empirical evidence has an important implication for the design of a policy to raise national savings, reduce real interest rates and raise investment.

Countries have very different philosophies about taxation and very different methods of collecting their revenue. During the past several decades, some countries have increased taxation quite dramatically while in other countries tax rates have remained roughly the same. Some countries incorporated value-added taxation in the 1960 while others shifted away from corporate taxation (USA).

Although research in the area of tax components changes has received only scant attention in the literature, according to Volkerink and De Haan (1999), with the more recent interest in growth theory and alternative economic policies that may result in economic growth, a number of researchers have concentrated their attention on the effect of tax policy changes on economic growth at both the micro and macro level.

In an initial study, Marsden (1983) found that the overall tax burden was significant in explaining variations in economic growth. Expanding his model to include specific tax categories (income, social security, taxes on goods and services, and taxes on international trade), Marsden showed that growth rates of investment were significantly related to the independent variables of corporate tax, domestic taxes on goods and services and foreign trade taxes. The personal income tax and social security taxes were not found to be significant.

The question that arises is whether these tax policy changes can alter a country's rate of economic growth in the long run. Even if theory predicts that the mix of direct and indirect taxes is an important determinant of long run growth and investment rates, in practice plausible changes in tax rates are unlikely to affect growth, even if they can alter moderately the investment rate.

Harberger (1964a) (1964b) claimed that while scientifically the most satisfying approach to study the growth effects of tax policy is to develop neoclassical intertemporal models the fact is that the US saving and growth rates have been invariant to large changes in the tax structure Harberger (1964a). Furthermore, using a growth-accounting framework he showed that changes in the mix of direct and indirect taxes have negligible effects on output growth because they have negligible effects on the growth of labor supply and on labor's income share and because their effect on savings and investment rates is not sufficiently large Harberger (1964b). Thus, in Harberger's view tax policy appears to be "superneutral": changes in tax policy may affect investment rates, and improve welfare though efficiency gains, but do not affect growth.

Marsden (1983) found that an increase of one percentage point in the tax revenue to GDP ratio resulted in a decrease of 0.36 percent in the rate of economic growth. He grouped countries by this ratio and examined the change in GDP. His analysis also included investment growth and labor force growth as dependent variables. Increasing the number of independent variables in his model by including specific tax components revealed that significant relationships existed but these relationships were not consistent for all dependent variables.

There is no clear evidence that the level of taxation along with other factors affecting the rate of return, does generally affect the level of household saving. Some studies claim to find a positive relationship, but some a negative one, many have concluded that there is no discernable effect. Certainly the enthusiasm for cuts in taxes on capital income among so many OECD countries might suggest a conviction that household saving would increase as tax rates were reduced.

Summers and Carroll (1987) in a series of regressions designed to explain the difference in saving rate between the USA and Canada found that tax incentives and disincentives affected saving rates.

Fitzgerald (1993), while examining the factors that influence private savings in Australia, argued that taxation of corporations' influences business savings, and it is the business savings that dominate private savings in Australia. Household savings play a minor role, with the savings ratio of the household sector being 2% in the 1990's. However, in developing countries like India, where the savings ratio of the household sector was around 19% in the 1990's, personal income tax policies can play a major role in determining household savings.

While estimating the savings determinants in Colombia, Gardenas and Escobar (1998) pointed out that much of the reduction in Colombian private savings during the period 1970-1994 was due to rises in taxation. Tax revenue as a percentage of GNP was used to measure the influence of taxation on private savings determinants. This coefficient was found to be negative and statistically significant. The other variables that influenced private savings were urbanization and age dependency.

The relationship between investment and taxation is relatively well established. In particular, Marsden (1983) showed that an increase of one point in the tax/GDP ratio lowered the growth rate of investment by 0.66 percent. He also examined the growth rate of investment using tax ratios for several tax components. His regression analysis found that domestic tax on goods and services (e.g. sales tax or value added tax) was the only significant independent variable.

Recently, Dahan and Hercowitz (1998) carried out an empirical study of the Israeli economy which displayed a large variability in both the national savings rate and tax rates during the period 1960-1994. The large variability of the income tax rate and the small open Israeli economy clearly showed that savings are sensitive to shocks. The percentage change in the rate of savings resulting from changes in the income tax rate was estimated to be - 0.29.

Economic growth is based mostly on raising the savings rate and the level of investment. If there is a discernible influence of tax policy on savings, capital accumulation and economic growth then there are many lessons that we should learn from the developing countries, from the tax structure and tax policies adopted by mature developed economies and those growing rapidly (Asian Tigers) Kerr and MacDonald (1999).

The purpose of this paper is to examine the stationarity of the data and the order of integration using Dickey-Fuller test. Following, we test the hypothesis of long run relationship among tax variables and economic indicators adopting the methodology of cointegration suggested by Johansen and Juselious.

The paper is organized as follows. Section 2 presents model specification and the data used for the analysis of the relationship between tax variables and economic indicators. Section 3 provides the results of unit root test. Section 4 focuses on cointegration and Johansen test. Following, section 5 describes seemingly unrelated regression functions. Section 6 presents the empirical results of the regression functions and finally, section 7 concludes.

2. Data and model specification

For the analysis of the relationship between taxes and economic indicators the following function is used:

$$Y_i = \beta_o + \beta_j X_j + e_i \qquad (1)$$

where:

Y_i are the endogenous variables of the model (GDP, SAV, INV)

X_j are predetermined variables of the model (TTX, TPI, TCI, TSS, TPP, TSV, TOC, TDS)

and e_i is the error term[1]

In order to avoid multicollinearity, we split the initial model into two. Splitting the primary model gives one model with TTX (total tax revenue) and TDS (surplus/deficit) as independent variables, and a second model with the rest of tax components in the function.

In every empirical research, the first step that we should take into consideration is the description of basic variables used in each analysis in order to give an overall view to every researcher for the variables used. The dependent variables used here are:

GDP = Change rate of Gross domestic product (as a percentage) (Annual percentage price changes of gross domestic product)

SAV = Percentage of private savings of Gross Domestic Product.

INV = Percentage of private investment of Gross Domestic Product

Each of these three variables is of vital importance to the policy makers and can be influenced by the tax structure of a country. The change rate of Gross Domestic Product (GDP) is used as an indicator for the total inclination in a particular economy. The savings indicator (SAV) as a percentage shows the response of the population to tax structure compared with consumption. The investment indicator (INV) as a percentage shows a slight reaction to tax structure but only for private investment.

Independent variables consist primarily of revenue-source variables. They are total tax revenue (TTX) divided by GDP, personal income tax (TPI), corporate income tax (TCI), payroll taxes (TSS), property tax (TPP), consumption taxes (i.e. sales taxes and value added taxes) (TSV), other taxes (indirect taxes and import/export duties) (TOC) and the governments' deficit or surplus (TDS) divided by total tax revenue. Deficit/surplus are included as an independent variable. Kormendi (1983) examined the use of deficit financing in connection with tax reduction[2].

The examined period starts from 1965 until 2002. Data for this research are obtained from OECD Revenue Statistics of Member Countries and OECD National Accounts published by Organization for Economic Cooperation and Development OECD.

If these variables have a common stochastic trend and the first differences are stationary, 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 (1979) (ADF) unit root test is used for the estimation of individual time series with intention to provide evidence as to when the variables are integrated.

3. 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 (in order to avoid spurious regression[3]) using the Augmented Dickey - Fuller (ADF) (1979) test on the following regression:

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

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

$$H_0 : \delta_2 = 0 \quad H_\varepsilon : \delta_2 < 0$$

The results of these tests appear in Table 1. The minimum values of the Akaike (AIC) (1973) and Schwarz (SC) (1978) 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 non-cointegration against the alternative that is the existence of cointegration using the Johansen (1988) maximum likelihood procedure, Johansen and Juselious (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.

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 p=3 is the appropriate specification for the above relationship. Further on we determine the cointegration vectors of the model, under the condition that tables 2a, 2b, 2c, 2d, 2e and 2f have order r<n (n=3 or n=7). The procedure of calculating order r is related to the estimation of the characteristic roots (eigenvalues), which are the following:

λ_1 = 0.32590 λ_2 = 0.26115 λ_3 = 0.13225 (GDP, TTX, TDS)

λ_1 = 0.33255 λ_2= 0.24195 λ_3= 0.08502 (SAV, TTX, TDS)

λ_1 = 0.47316 λ_2= 0.23008 λ_3= 0.12647 (**INV,** TTX, TDS)

TABLE 2A

Johansen and Juselious Cointegration Test
Variables GDP, TTX, TDS
(Maximum lag in VAR = 3)

Eigenvalues			**Critical Values**	
Null	Alternative	Eigenvalue	95%	90%
r = 0	r = 1	23.8034	22.0400	19.8600
r = 1	r = 2	10.5933	15.8700	13.8100
r = 2	r = 3	4.9648	9.1600	7.5300
Trace Statistic			**Critical Values**	
Null	Alternative	Eigenvalue	95%	90%
r = 0	r > 0	39.3615	34.8700	31.9300
r =< 1	r > 1	15.5581	20.1800	17.8800
r= < 2	r = 2	4.9648	9.1600	7.5300

TABLE 2B

Johansen and Juselious Cointegration Test
Variables SAV, TTX, TDS (Maximum lag in VAR = 3)

Eigenvalues			**Critical Values**	
Null	Alternative	Eigenvalue	95%	90%
r = 0	r = 1	14.1502	22.0400	19.8600
r = 1	r = 2	9.6954	15.8700	13.8100
r = 2	r = 3	3.1398	9.1600	7.5300
Trace Statistic			**Critical Values**	
Null	Alternative	Eigenvalue	95%	90%
r = 0	r > 0	26.9853	34.8700	31.9300
r =< 1	r > 1	12.8352	20.1800	17.8800
r= < 2	r = 2	3.1398	9.1600	7.5300

TABLE 2C

Johansen and Juselious Cointegration Test
Variables INV, TTX, TDS (Maximum lag in VAR = 3)

Eigenvalues			**Critical Values**	
Null	Alternative	Eigenvalue	95%	90%
r = 0	r = 1	22.4301	22.0400	19.8600
r = 1	r = 2	9.1515	15.8700	13.8100
r = 2	r = 3	4.7325	9.1600	7.5300
Trace Statistic			**Critical Values**	
Null	Alternative	Eigenvalue	95%	90%
r = 0	r > 0	36.3141	34.8700	31.9300
r= < 1	r > 1	13.8840	20.1800	17.8800
r= < 2	r = 2	4.7325	9.1600	7.5300

The results in Tables 2a, 2b, 2c suggest that the number of statistically significant cointegration vectors is equal to 1 (except for table 2b where no cointegration vector exists) and are the following:

$$GDP = 38.1707 - 0.89381TTX - 0.18153\ TDS \quad (3)$$

$$INV = 31.8345 - 0.06815TTX - 0.17242\ TDS \quad (4)$$

In the second model, the characteristic roots (eigenvalues) for the rest of tax variables are presented below.

$\hat{\lambda}_1 = 0.90086$ $\hat{\lambda}_2 = 0.80470$ $\hat{\lambda}_3 = 0.78674$ $\hat{\lambda}_4 = 0.54087$ $\hat{\lambda}_5 = 0.41483$
$\hat{\lambda}_6 = 0.32329$ $\hat{\lambda}_7 = 0.045813$ (GDP, TPI, TCI, TSS, TPP, TSV, TOC)
$\hat{\lambda}_1 = 0.93783$ $\hat{\lambda}_2 = 0.78324$ $\hat{\lambda}_3 = 0.70121$ $\hat{\lambda}_4 = 0.66132$ $\hat{\lambda}_5 = 0.30030$
$\hat{\lambda}_6 = 0.14547$ $\hat{\lambda}_7 = 0.11928$ (SAV, TPI, TCI, TSS, TPP, TSV, TOC)
$\hat{\lambda}_1 = 0.82575$ $\hat{\lambda}_2 = 0.80463$ $\hat{\lambda}_3 = 0.71882$ $\hat{\lambda}_4 = 0.60577$ $\hat{\lambda}_5 = 0.49956$
$\hat{\lambda}_6 = 0.10529$ $\hat{\lambda}_7 = 0.046157$ (INV, TPI, TCI, TSS, TPP, TSV, TOC)

TABLE 2D

Johansen and Juselious Cointegration Test
Variables GDP, TPI, TCI, TSS, TPP, TSV, TOC
(Maximum lag in VAR=3)

Eigenvalues			**Critical Values**	
Null	Alternative	Eigenvalue	95%	90%
r = 0	r = 1	80.8913	46.4700	43.4400
r = 1	r = 2	57.1619	40.5300	37.6500
r = 2	r = 3	54.0828	34.4000	31.7300
r = 3	r = 4	27.2446	28.2700	25.8000
r = 4	r = 5	18.7549	22.0400	19.8600
r = 5	r = 6	13.6678	15.8700	13.8100
r = 6	r = 7	1.6414	9.1600	7.5300
Trace Statistic			**Critical Values**	
Null	Alternative	Eigenvalue	95%	90%
r = 0	r > 0	253.4446	132.4500	127.2400
r= < 1	r > 1	172.5532	102.5600	97.8700
r= < 2	r > 2	115.3914	75.9800	71.8100
r= < 3	r > 3	61.3086	53.4800	49.9500
r= < 4	r > 4	30.0640	34.8700	31.9300
r= < 5	r > 5	15.3091	20.1800	17.8800
r= < 6	r = 6	1.6414	9.1600	7.5300

TABLE 2E

Johansen and Juselious Cointegration Test
Variables SAV, TPI, TCI, TSS, TPP, TSV, TOC
(Maximum lag in VAR = 3)

Eigenvalues			**Critical Values**	
Null	Alternative	Eigenvalue	95%	90%
r = 0	r = 1	97.2265	46.4700	43.4400
r = 1	r = 2	53.5131	40.5300	37.6500
r = 2	r = 3	42.2807	34.4000	31.7300
r = 3	r = 4	37.8943	28.2700	25.8000
r = 4	r = 5	12.4985	22.0400	19.8600
r = 5	r = 6	5.5020	15.8700	13.8100
r = 6	r = 7	4.4457	9.1600	7.5300
Trace Statistic			**Critical Values**	
Null	Alternative	Eigenvalue	95%	90%
r = 0	r > 0	253.3608	132.4500	127.2400
r= < 1	r > 1	156.1343	102.5600	97.8700
r= < 2	r > 2	102.6212	75.9800	71.8100
r= < 3	r > 3	60.3404	53.4800	49.9500
r= < 4	r > 4	22.4462	34.8700	31.9300
r= < 5	r > 5	9.9477	20.1800	17.8800
r= < 6	r = 6	4.4457	9.1600	7.5300

TABLE 2F

Johansen and Juselious Cointegration Test
Variables INV, TPI, TCI, TSS, TPP, TSV, TOC
(Maximum lag in VAR = 3)

Eigenvalues			**Critical Values**	
Null	Alternative	Eigenvalue	95%	90%
r = 0	r = 1	61.1548	46.4700	43.4400
r = 1	r = 2	57.1504	40.5300	37.6500
r = 2	r = 3	44.4066	34.4000	31.7300
r = 3	r = 4	32.5792	28.2700	25.8000
r = 4	r = 5	14.2296	22.0400	19.8600
r = 5	r = 6	3.8938	15.8700	13.8100
r = 6	r = 7	1.6539	9.1600	7.5300

cont'd

Trace Statistic			**Critical Values**	
Null	Alternative	Eigenvalue	95%	90%
r = 0	r > 0	225.0683	132.4500	127.2400
r= < 1	r > 1	163.9135	102.5600	97.8700
r= < 2	r > 2	106.7631	75.9800	71.8100
r= < 3	r > 3	62.3566	53.4800	49.9500
r= < 4	r > 4	29.7774	34.8700	31.9300
r= < 5	r > 5	5.5478	20.1800	17.8800
r= < 6	r = 6	1.6539	9.1600	7.5300

The results in Tables 2d, 2e, 2f suggest that the number of statistically significant cointegration vectors is equal to 4.

$$GDP = 271.888 - 1.711TPI - 8.787TCI - 1.461TSS + 1.289TPP - 4.848TSV - 3.398\ TOC \quad (5)$$

$$SAV = 119.110 - 7.065TPI - 20.138TCI - 3.513TSS - 15.489TPP - 1.318TSV + 4.648TOC \quad (6)$$

$$INV = 419.941 + 15.023TPI - 24.078TCI + 0.568TSS + 40.948TPP + 19.339TSV -19.035TOC \quad (7)$$

The valuations of coefficients in equilibrium relationships, which are in fact the long-run estimated elasticities relatively to economic indicators and taxes, show that total taxes and deficit in relation to economic indicators are inelastic (function 3 and 4), contrary to the rest tax categories which are elastic (function 5, 6 and 7).

Moreover, taken the results of functions 3 and 4, we conclude that in the long run, the increase of total taxes just like the increase of deficit, reduce the change rate of GDP and private investment.

From the results of functions 5, 6 and 7 we can see that in the long run, the increase of personal income tax decreases the change rate of GDP and saving and increases investment, corporate income tax and consumption tax provides a negative sign for the three economic indicators, payroll tax reduces the change rate of GDP and saving and increases investment, and property tax increases the change rate of GDP and saving and reduces investment. Finally, other indirect taxes decrease the change rate of GDP and investment and give rise to saving.

Taking into consideration that all examined variables used in the model are cointegrated of order 1 and cointegration relationships exist among these variables, we proceed with the method of seemingly unrelated regression (SUR).

5. Seemingly Unrelated Regression Model

When an equation consists of one endogenous variable in a system of structural equations, then we claim that this is not a system of simultaneous equations but a set of equations and can be written as:

$$Y_i = X_i \beta_i + \varepsilon_i, \text{ for } i = 1,2,\ldots\ldots G \quad (8)$$

Where for each function i we have:

Y_i = vector $\eta \; x$ 1 of the dependent variable

X_i = matrix $\eta \; x$ K_i of the dependent variable

β_i = vector K_i x 1 of regression coefficients

ε_i = vector n x 1 of error term

The set of equations is presented below

$$\underset{Gn\times 1}{\begin{bmatrix} Y_1 \\ Y_2 \\ . \\ . \\ Y_G \end{bmatrix}} = \underset{Gn\times K}{\begin{bmatrix} X_1 \ldots 0 \ldots\ldots 0 \\ 0 \ldots\ldots X_2 \ldots\ldots 0 \\ \ldots\ldots\ldots\ldots\ldots \\ \ldots\ldots\ldots\ldots\ldots \\ 0 \ldots 0 \ldots\ldots X_G \end{bmatrix}} \underset{K\times 1}{\begin{bmatrix} \beta_1 \\ \beta_2 \\ . \\ . \\ \beta_G \end{bmatrix}} + \underset{Gn\times 1}{\begin{bmatrix} \varepsilon_1 \\ \varepsilon_2 \\ . \\ . \\ \varepsilon_G \end{bmatrix}}$$

where $K=K_1+K_2 + \ldots\ldots K_G$

In case where error terms are consistent with the hypotheses of linear regression and there is no correlation, using the same t=1,2,...,n, between the error terms of two different equations (i j), then OLS can still solve for one equation at a time. The coefficients are:

$$b_{iOLS} = (X_i^{/} X_i)^{-1} X_i^{/} Y_i$$

and

$$\text{Var-cov } (b_{i.OLS}) = s_i^2 (X_i^{/} X_i)^{-1}$$

where

b_i = β_i estimator

$$s_i^2 = \frac{1}{n-K_i} \sum_{j=1}^{n} e_j^2 = \frac{1}{n-K_i} e_i^{/} e_i$$

e_i = ε_i estimator

In case where error terms are consistent with the hypotheses of linear regression and there is correlation, using the same t=l,2,...,n, between the error terms of two different equations (i j), in other words we have contemporaneous correlation, where then we cannot apply the OLS method for one equation at a time. In contrast, we use the method of seemingly unrelated regression (SUR). Under these circumstances, the coefficients we use are the following Zellner (1962).

$$b_{SUR} = (X^{/} W^{-1} X)^{-1}\ X^{/} W^{-1} Y$$

and

$$\text{var-cov}(b_{SUR}) = (X^{/} W^{-1} X)^{-1}$$

where

$$W = \begin{bmatrix} s_{11}I \ldots\ldots s_{12}I \ldots\ldots\ldots\ldots s_{1G}I \\ \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \\ \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \\ s_{21}I \ldots\ldots s_{22}I \ldots\ldots\ldots\ldots s_{2G}I \\ s_{G1}I \ldots\ldots s_{G2}I \ldots\ldots\ldots\ldots s_{GG}I \end{bmatrix}$$

$$e_{i,OLS} = Y_i\text{-}Xib_{iOLS}$$

$$s_{ij} = \frac{1}{[(n-K_i)(n-K_j)]^{1/2}} e_{i,OLS}^{/} e_{i,OLS} = \frac{1}{[(n-k_i)(n-K_j)]^{1/2}} \sum_{t=1}^{n} e_{it} e_{jt}$$

$$\lambda = n \sum_{i=2}^{G} \sum_{j=1}^{i-1} r_{ij}^2 \quad \sim \quad \chi^2 \left[\frac{G(G-1)}{2} \right]$$

where

$$r_{ij}^2 = \frac{s_{ij}^2}{s_{ii} s_{jj}}$$

Therefore, the next step is to examine if there is correlation between error terms of two or more equations (i j). In other words, we have to search for contemporaneous correlation between the error terms in the model. The two hypotheses examined are:

Ho: σ_{ij} =0 (i j) => non existence of contemporaneous correlation

Ha: at least one σ_{ij} 0 => existence of contemporaneous correlation

Under the null hypothesis Breusch and Pagan (1980), based on the Lagrange multiplier, examined the existence or non- existence of contemporaneous correlation, presented as:

$$LM = n \sum_{i=2}^{G} \sum_{j=1}^{i-1} r_{ij}^2$$

where

$$r_{ij}^2 = \frac{s_{ij}^2}{s_{ii} s_{jj}}$$

Asymptotically for this statistic holds:

$$LM \sim \chi^2\left[\frac{G(G-1)}{2}\right]$$

In order to avoid multicollinearity we split the basic model into two. Splitting the primary model gives one model with TTX (total tax revenue) and TDS (deficit/surplus) as independent variables and a second one with the rest of the tax components as independent. Therefore, in this case we get two systems of structural equations where each one consists of one endogenous variable.

For every system we examine if there exists contemporaneous correlation between error terms in order to apply the SURE approach.

6. Empirical Results

The purpose of the paper is to test the effect of tax variables on economic growth, saving and investment. Below, matrix r of correlation coefficients of the residuals is presented, derived from the valuations of the first system.

$$r = \begin{bmatrix} 1.00000.....0.39781.......0.31069 \\ 0.39781....1.00000.......0.65944 \\ 0.31069.....0.65944......1.00000 \end{bmatrix}$$

According to the above matrix the Lagrange multiplier statistic is

$$LM = n(r_{21}^2 + r_{31}^2 + r_{32}^2) = 26.14$$

Taking into consideration that G=3, degrees of freedom for χ^2 equals G(G-1)/2=3 and the level of significance is 5%, we get the result χ^2 (3)= 7.81. As long as the value of the Lagrange multiplier is larger to critical value, the null hypothesis is rejected. Therefore, we conclude that there is contemporaneous correlation between error terms in the first system and we can apply the SURE approach.

TABLE 3A

Parameters' estimates of variables (SURE)

	Economic Variables		
	GDP	**SAV**	**INV**
TTX	-0.63711 [0.000] *	-0.57506[0.0001*	-0.17822[0.027]**
TDS	-0.22323[0.0011*	0.0815[0.061]***	-0.09617[0.013]**
R^2	0.419	0.661	0.371
F	F(2,35) = 12.66[0.000]*	F(2,35) = 34.13f0.0001*	F(2,35) = 10.32[0.000|*

* Level of Significance 1%
** Level of Significance 5%
*** Level of Significance 10%

TABLE 3B

Parameters' estimates of variables (SURE)

	Economic Variables		
	GDP	**SAV**	**INV**
TPI	-2.804[0.0641***	-2.408[0.043]**	-2.182f0.0171**
TCI	NA	-1.815[0.099]***	-2.112f0.0141**
TSS	2.831[0.000]*	NA	NA
TPP	-3.743[0.005]*	NA	NA
TSV	-1.239[0.051]**	-1.339[0.000]*	NA
TOC	-1.951[0.005]*	NA	0.889[0.001]*
R^2	0.546	0.418	0.314
FF	F(5,32) = 7.466 [0.000]	F(3,34) = 8.152 [0.000]	F(3,34) = 5.194 [0.005]

* Level of Significance 1%
** Level of Significance 5%
*** Level of Significance 10%

High values of R^2 and the significance of F distribution indicate the robust relationship for the three economic indicators in both functions. The significance of independent variables is determined in the regression valuation

The results of table 3a show the robust relationship between total taxes (TTX), the change rate of GDP and saving having a negative sign and the coefficient of total taxes to be statistical significant in 1% level. An equivalent robust negative relationship is found between total taxes (TTX) and investment in 5% level of significance. The coefficient valuations, which in fact are the estimated elasticities relatively to the change rate of GDP, saving and investment, indicate that total taxes are inelastic in all examined variables.

As far as deficit or surplus is concerned, the sign is positive for the two economic variables (saving and investment) showing that a surplus will increase the level of saving and investment in Greece. The estimation of the parameter of deficit/surplus is quite coherent with economic theory and statistical significant in 10% and 5% level for saving and investment, while for the change rate of GDP this estimation is more constant.

Parameters' estimations of the tax variables, in the second function, are presented in table 3b. Personal income tax (TPI) has a positive sign for saving and investment and is negative for the change rate of GDP. This result present that an increase on the rate of tax revenue stemming from personal income tax (TPI) will increase savings and investment and decrease the change rate of GDP. Consumption taxes (TSV) show a negative sign not only for the change rate of GDP but also for saving and investment.

Corporate income tax (TCI) has a positive sign for saving and investment but is not statistically significant for the change rate of GDP. The interpretation of these results is that taxpayers invest on corporations, reducing the current income and deferring tax payment. An increase in the three aforementioned taxes (personal income, corporate income and consumption) will give rise to investment but result in the reduction of the change rate of GDP.

Property tax (TPP) appears to be statistically significant for the change rate of GDP. Parameter's estimation gives a negative sign indicating that an increase on property taxes will reduce the change rate of GDP. Other taxes (TOC) gave mixed results for the three economic indicators. Finally, payroll taxes (TSS) are not consistent with correlations. Explanation from this analysis cannot be given due to ambiguous indication of this variable.

7. Conclusion

This paper employs with the relationship between tax revenue and three economic indicators using annual data for the period 1965-2002. Empirical analysis showed that tax components and economic indicators in Greece present a unit root. On this basis, we used cointegration analysis suggested by Johansen and Juselious so that long run equilibrium comes up between tax variables and economic indicators. The results of this long run relationship show that an increase of total taxes and deficit reduce the change rate of GDP and private investment. Also, the rise of personal income tax (TPI) will increase savings and decrease the change rate of GDP and investment, corporate income tax reduces the three economic indicators, payroll tax reduces the change rate of GDP and saving and increases investment and property tax increase the change rate of GDP and saving and reduces investment. The three economic indicators fell by consumption taxes and finally other indirect taxes decrease the change rate of GDP and investment and give rise to saving.

The SURE approach was applied for the relationship of tax categories and economic indicators. The results showed that relationships exist between tax categories and economic indicators and are significant. Particularly, there is robust negative relationship between total taxes and economic indicators. A similar relationship found on deficit and the change rate of GDP and investment but was found to be positive for saving.

Variables that seem to have a negative effect on the change rate of GDP are income tax, consumption tax, property tax and other taxes. Saving is affected negatively by income tax, corporate income tax and consumption tax. Finally, investment is affected positively by other indirect taxes and negatively by personal and corporate income tax.

All the above are generalities concerning Greece and may not be applicable for other countries. The analysis shows that this situation can change when an increase on corporate tax or consumption tax or some other tax occurs.

Notes

1. Due to the fact that autocorrelation of the residuals is presented in time series, we consider the values of error term are based on a first order autoregressive scheme AR (1), that is: $u_t = \rho u_{t-1} + e_t$

2. Natural logarithms of tax shares are not taken due to zero shares for some taxes in some countries and negative values for deficits.

3. The problem of spurious regression occurs when two time series have a high correlation while there is no actual relationship between them. High correlation is due to the existence of time trend on both time series (Granger and Newbold 1974).

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