STOCHASTIC FRONTIER ANALYSIS: EMPIRICAL EVIDENCE ON GREEK PRODUCTIVITY

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1 Efficiency as deviation from a frontier[1]

Efficiency, namely, the utilization of resources, is one of the most important topics of economic theory. Efficiency is the relationship between what an organization (producer, production unit, or any decision - making unit) produces and what it could feasibly produce, under the assumption of full utilization of the resources available (Hoyo et al., 2004) Within this conceptual framework, as stated by Kumbhakar and Lovell (2000, p. 15):

> "efficiency represents the degree of success which producers achieve in allocating the available inputs and the outputs they produce, in order to achieve their goals ... namely ... to attain a high degree of efficiency in cost, revenue, or profit".

As stated in del Hoyo et al. and Kumbhakar and Lovell (2000), efficiency is the ability of a decision – making unit to obtain the maximum output from a set of inputs (output orientation) or to produce an output using the lowest possible amount of inputs (input orientation). A production frontier refers to the maximum output attainable by given sets of inputs and existing production technologies . The production frontier defines the technical efficiency in terms of a minimum set of inputs in order to produce a given output or a maximum output produced by a given set of inputs. This approach involves selecting the mix of inputs which produces a given quantity of output at a minimum cost, namely the production frontier. If what a producer actually produces is less than what it could feasibly produce then it will lie below the frontier. The

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distance by which a firm lies below its production frontier is a measure of the firm's inefficiency (Bera and Sharma, 1999) .

Farrell (1957) was the first to empirically measure productive efficiency in terms of deviations from an ideal frontier. He also proposed a decomposition of economic efficiency into: a) technical efficiency (TE), which measures the ability of a firm to obtain the maximum output from given inputs, and b) allocative efficiency (AE), which measures the ability of a firm to use inputs in optimal proportions given their prices:

Economic efficiency=Technical efficiency+allocative efficiency

If the only information available are input and output quantities, and there is no information on input or output prices, then the type of efficiency that can be measured is technical efficiency. If price information on inputs and outputs is available, in addition to input and output quantities, then the type of efficiency that can be measured is allocative efficiency. Profit maximisation requires a firm to be both technically efficient (by producing the maximum output given the level of inputs employed), as well as allocative efficient (by using the right mix of inputs, or producing the right mix of outputs given their relative prices, respectively (Kumbhakar and Lovell, 2000). Nevertheless, in real economic life, producers are hardly fully productive efficient. The difference can be explained in terms of technical and allocative inefficiencies, as well as a range of unforeseen exogenous shocks, making it unlike all (or even any) producers, firms or, even, economies operate at the full efficiency frontier (Reifschneider and Stevenson, 1991). However, one of the main related questions is whether inefficiency occurs randomly, or whether some economic agents (producers, firms or economies) have predictably higher levels of inefficiency than others. That is the reason why estimating efficiency is one of the core tools of economic analysis. Firstly, efficiency estimation provides an indication of the percentage by which potential output could be increased, or potential cost could be decreased, in relation to the corresponding production frontier. The further below the frontier a producer lies, the more inefficient it is[2].

Regarding that the production frontier cannot be observed directly, several techniques have been developed in order to estimate efficiency. As broadly described in del Hoyo et al (2004) and Kortelainen (2008), the main methods of production frontiers and efficiency estimation may be classified into two core groups:

a) non − parametric models, regarding Data Envelopment Analysis, developed by Farrell (1957) and Charnes et al (1978), and

b) parametric models, regarding Deterministic Frontier Analysis and Stochastic Frontier Analysis, developed by Aigner et al, (1977) and Meeusen and van den Broeck (1977).

[2] The type of efficiency that can be measured using a production possibility frontier is technical efficiency.

2 Deterministic production frontier models and technical efficiency

Aigner and Chu (1968) were the first researchers to estimate a deterministic frontier production function using Cobb-Douglas production function. They argued that, within a given industry, firms might differ from each other in their production processes, due to certain technical parameters in the industry, due to differences in scales of operation or due to organizational structures. Under this assumption, they considered a Cobb - Douglas production function, with an empirical frontier production model such as:

$$q_{it} \leq f(\mathbf{x}_{it}) \tag{1}$$

This equation defines a production relationship between inputs, $\mathbf{x}$, and output q_{it}, in which for any given $\mathbf{x}$, the observed value of q_{it} must be less or equal to $f(\mathbf{x}_{it})$. Since the theoretical production function is an ideal (the frontier of efficient production), any non - zero disturbance is considered to be the result of inefficiency, which must have a negative effect on production function:

$$q_{it} = f(\mathbf{x}_{it}) - u_{it}, i = 1, 2, 3, 4, ..., I, t = 1, ..., N \tag{2}$$

Taking natural logarithms, the model becomes:

$$\ln q_{it} = \beta_0 + \ln \mathbf{x}_{it}\boldsymbol{\beta} - u_{it} \tag{3}$$

where:

1. $\ln q_{it}$ is the natural logarithm of the output of the i^{th} firm;
2. $\ln \mathbf{x}_{it}$ is the natural logarithms of inputs;
3. $\boldsymbol{\beta}$ is a column vector of the unknown parameters to be estimated;
4. u_{it} is a non – negative random variable associated with technical inefficiency, representing the shortfall of actual output from its maximum possible value.

Technical efficiency for the i^{th} firm is defined as the ratio of the observed output for the i^{th} firm relative to the potential output (frontier function):

$$\begin{aligned} TE_{it} &= \frac{observed\ output}{potential\ \max imum\ output} = \\ &= \frac{q_{it}}{\exp(\mathbf{x}_{it}\boldsymbol{\beta})} = \frac{\exp(\mathbf{x}_{it}\boldsymbol{\beta} - u_{it})}{\exp(\mathbf{x}_{it}\boldsymbol{\beta})} = \end{aligned} \tag{4}$$

$$= \exp(-u_{it})\ , 0 \leq TE_{it} \leq 1 \tag{5}$$

and

$$u_{it} = \ln(TE_{it}) \tag{6}$$

Technical efficiency measure takes a value between zero and one:

1. $TE_{it} = 1$ shows that the producer is fully productive efficient and, correspondingly, the observed output q_i reaches its maximum obtainable value,

2. $TE_{it} < 1$ provides a measure of the shortfall of the observed output from maximum feasible output.

Letting:

$$TE_{it} = \exp(-u_{it}) \ , 0 \leq TE_{it} \leq 1 \tag{7}$$

will ensure that the observed output lies below the frontier, that is:

$$q_{it} \leq f(\mathbf{x}_{it}\beta) \tag{8}$$

Nevertheless, in this case, the model is deterministic, and all deviations form the frontier are assumed to be the result of technical inefficiency and no account is taken of any measurement errors (i.e. errors associated with the choice of functional form) or any statistical noise (i.e. omission of relevant variables from the vector $\mathbf{x}_{it}$).This approach is dealt by the Stochastic Production Frontier models.

3 Stochastic production frontier models and technical efficiency

In the decade of 1970, deterministic production frontier model was extended by Afriat (1972), and more systematically by Aigner et al. (1977) and Meeusen and van den Broeck (1977). Based on the literature commencing with theoretical work by Debreu (1951) and Farrell (1957), Aigner et al. (1977) and Meeusen and van den Broeck (1977) extended the deterministic frontier appoach in order to account not only for technical inefficiency, but also for any measurement errors or any statistical noise[3]. They developed a statistically and theoretically sound method for measuring efficiency, different is the sense that it allows random events to contribute to variations in producer output. Aigner et al. (1977) and Meeusen and van den Broeck (1977) proposed, almost simultaneously, but

[3]Since the introduction of stochastic frontier analysis, it has been widely accepted that frontier models provide a number of advantages over non-frontier models (see, e.g., Forsund et al., 1980 and Bravo-Ureta and Pinherio, 1993). The economic literature on efficiency and stochastic frontier analysis has been rather extensive with numerous studies. To name just a few, there are influential research papers by Forsund et al. (1980) and Greene (1993, 1997), Bauer (1990), Battese (1992), Schmidt (1985), Cornwell and Schmidt (1996), Kalirajan and Shand (1999), and Murillo-Zamorano (2004), as well as book-length approaches, including Coelli et al. (1995), Coelli et al. (1998), Kumbhakar and Lovell (2000) and Fried et al (2008).

independently, a formulation within which observed deviations from the production function could arise from two sources: a) productive inefficiency, that would necessarily be negative, and b) effects specific to the firm, that could be of either sign. The model is In order to incorporate this feature, there is need to introduce another random variable representing any statistical noise or measurement errors. In order to capture this, the stochastic model includes a composite error term that sums a two-sided error term, measuring all effects outside the firm's control, and a one-sided, non-negative error term, measuring technical inefficiency. The resulting frontier is presented in terms of a general production function, known as a 'stochastic production frontier'

$$\ln q_{it} = \mathbf{x}_{it}\boldsymbol{\beta} + v_{it} - u_{it} \tag{9}$$

where the observed response q_{it} is a scalar output, $\mathbf{x}_{it}$ is a vector of m inputs, $\boldsymbol{\beta}$ is a vector of the unknown technology parameters, $f(\mathbf{x}_{it}\boldsymbol{\beta})$ is the production frontier. As described in Coelli et al. (2005), in this case, a Cobb – Douglas stochastic frontier model takes the form:

$$\ln q_{it} = \beta_0 + \beta_1 \ln x_{it} + v_{it} - u_i t \tag{10}$$

or

$$q_i t = \exp(\beta_0 + \beta_1 \ln x_{it} + v_{it} - u_{it}) \tag{11}$$

or

$$q_i t = \exp(\beta_0 + \beta_1 \ln x_i t) \times \exp(v_{it}) \times \exp(-u_{it}) \tag{12}$$

where,

1. $\exp(\beta_0 + \beta_1 \ln x_{it})$: deterministic component
2. $\exp(v_{it})$: noise
3. $\exp(-u_{it})$: inefficiency

The model equation can be rewritten as:

$$q_{it} = f(\mathbf{x}_{it}\beta) \times \exp(v_{it} - u_{it}), u_i \geq 0 \tag{13}$$

where u_i represents the shortfall of output from the frontier. The composite error structure is:

$$\epsilon_{it} = v_{it} - u_{it} \tag{14}$$

The stochastic econometric approach enables to attempt to distinguish the effects of noise and inefficiency, thereby providing the basis for statistical inference. The model is such that the possible production q_{it} is limited above by the stochastic quantity $f(x_{it},\beta)\times\exp(v_{it})$. The noise component v_{it} is assumed to be independently and identically distributed (i.i.d.), symmetric, and distributed indepedently of u_{it}. The combined error term $\epsilon_{it}=v_{it}-u_{it}$ is therefore asymmetric since $u_{it}\geq 0$. Providing estimates of producer - specific technical efficiency, which is the ultimate objective of the estimation process in addition to obtaining estimates of the production technology parameters β in $f(x_{it},\beta)$, requires an extraction of separate estimates of statistical noise v_i and technical inefficiency u_{it} form the estimates of ϵ_{it} for each producer. therefore, the distributional assumptions of the inefficiency term are required to estimate the technical inefficiency of each producer.

In order to define technical efficiency within the stochastic frontier framework, let us consider the above production function:

$$q_{it}=f(\mathbf{x}_{it}\beta)+\varepsilon_{it} \tag{15}$$

Under the assumption for the error term and ensuring that observed output lies below the stochastic frontier, the production function becomes:

$$q_{it}\leq f(\mathbf{x}_{it}\beta)\times\exp(v_{it}) \tag{16}$$

Consequently, we have:

$$\begin{aligned} TE_{it} &= \frac{observed\ output}{potential\ \max imum\ output}= \\ &= \frac{f(\mathbf{x}_{it}\beta)\times\exp(v_{it})\times\exp(-u_{it})}{\exp(\mathbf{x}_{it}\boldsymbol{\beta})}= \\ &= \exp(-u_{it})\ ,0\leq TE_{it}\leq 1 \end{aligned} \tag{17}$$

which will ensure that the observed output lies below the frontier. As stated above, following the inclusion of the second random error, the stochastic frontier model asserts that the composite error term of the function is made up of two independent components: a) of a two – sided random term, v_{it}, and b) by a one – sided positive error term u_{it}. The component v_{it} represents factors that cannot be controlled by production units, measurement errors, and left-out explanatory variables. On the other hand, the component u_{it} represents the shortfall from the production frontier due to inefficiency, which may be the result of cultural factors, such as attitude toward work; climatic factors, such as summers, or traditions, such as religious holidays.

Aigner et al. (1977) assumed that the stochastic error terms v_{it} are independent and identically distributed (i.i.d.) normal random variables with mean zero and constant variance σ_v^2:

$$(v_{it})\ \tilde{}\, iidN(0,\,\sigma_v^2) \tag{18}$$

which denotes that the errors v_{it} are independently and identically distributed normal random variables with zero means and variances σ_v^2 , and

$$(u_{it}) \ \tilde{}\ iidN(0,\, \sigma_u^2) \tag{19}$$

which denotes that the errors u_{it} are independently and identically distributed normal random variables with zero means and variances σ_u^2.

The model assumes that each v_{it} is distributed independently of each u_{it} and that both errors are uncorrected with the explanatory variables in x_i. In addition, it is assumed that:

1. E$(v_{it}) = 0$ (zero mean)
2. E$(v_i^2) = \sigma_v^2$ (homoskedastic)
3. E$(v_{it}v_{jt}) = 0$, for all $i \neq j$ (uncorrelated)
4. E$(u_i^2) =$ constant (homoskedastic)
5. E$(u_i\ u_j) = 0$, for all $i \neq j$ (uncorrelated)

For simplicity reasons, we restrict attention to firms which produce only one output q_{it} using only one input x_{it}. Figure (2) shows the inputs and outputs of two firms A and B. The deterministic component of the frontier model has been drawn to reflect the existence of diminishing returns to scale. Values to the input are measured along the horizontal axis and outputs are measured on the vertical axis. Firm A uses the input level x_A to produce the output q_A, while

Firm B uses the input level x_B to produce the output q$_B$. If there were no inefficiency effects (that is, if $u_A = 0$ and $u_B = 0$), then the so-called frontier outputs for firms A and B would be:

$$q_A^* = \exp(\beta_0 + \beta_1 \ln x_A + v_A) \tag{20}$$

and

$$q_B^* = \exp(\beta_0 + \beta_1 \ln x_B + v_B) \tag{21}$$

It is clear that the frontier output for firm A lies above the deterministic part of the production frontier only because the noise effect is positive ($v_A > 0$), while the frontier output for firm B lies below the deterministic part of the frontier because the noise effect is negative ($v_B < 0$). It can also been seen that the observed output of firm A lies below the deterministic part of the frontier because the sum of the noise and inefficiency effects is negative ($v_A - u_A < 0$).

In this case, the prediction of technical efficiency is based on the conditional expectation

$$E(\exp(-\,\mathrm{u}_{it}) \mid \epsilon_{it}), \epsilon_{it} = v_{it} - u_{it} = y_{it} - f(\mathbf{x}_{it}) \tag{22}$$

where $\epsilon_{it} = v_{it} - u_{it}$ is the combined error term.

The first step in predicting the technical efficiency TE_i, is to estimate the parameters of the stochastic production frontier model. Even though, the entire term $(v_{it} - u_{it})$ is easily estimated for each observation, but a major problem is how to separate it into its two components. Estimation and hypothesis testing procedures in the case of stochastic frontiers is more complicated due to the fact that the right – hand side of the model includes two random terms – a symmetric error, v_i and a non – negative random variable u_i. Trying to solve this problem, the relationship between q_i and v_i could be also expressed as q_i ~$iidN(x_i\beta, \sigma^2)$, where q_i denotes the i^{th} observation on the dependent variable; $\mathbf{x}_i$ is a vector containing the explanatory variables; β_i is the associated vector of unknown parameters. The assumption of a certain inefficiency distribution as well as a normal noise distribution suggests the use of maximum likelihood estimation method (Behr and Tente, 2008), one of the commonly used methods of estimating the parameters of a stochastic frontier.

4 Stochastic Frontier model estimation - The Maximum Likelihood Estimation method

Since early, Aigner et al. (1977) first estimated the unknown parameters of the stochastic frontier model using the method of maximum likelihood ($M.L.$) method followed also widely in later decades by Greene (1982) and Coelli (1995), among others. Maximum likelihood ($M.L.$) estimation is a popular statistical method used for fitting a mathematical model to real world data. The concept of maximum likelihood ($M.L.$) estimation is based on the idea that a particular sample of observations is more likely to have been generated from some distributions than from others. Consequently, the maximum likelihood estimate of an unknown parameter is defined to be the value of the parameter that maximizes the probability (or likelihood) of randomly drawing a particular sample of observations.

In order to use the maximum likelihood principle to estimate the parameters of the production frontier function model, we make the assumption that the errors are normally distributed. This assumption is combined with the assumptions expressed above[4]:

1. $E(v_i) = 0$ (zero mean)
2. $E(v_i^2) = \sigma^2$ (homoskedastic)
3. $E(v_i\ v_j) = 0$, for all $i \neq j$ (uncorrelated).

Aigner et al. (1977) focused on the implicit assumption that the likelihood of inefficient behavior monotonically decreases for increasing levels of inefficiency. They parameterized the log – likelihood function for the half – normal model in terms of the variance parameters:

[4] For a detailed analysis, see Coelli et al. (2005)

$$\sigma^2 = \sigma_v^2 + \sigma_u^2 \tag{23}$$

where σ^2 is a measure of the total variance of the combined error term

$$\epsilon_{it} = v_{it} - u_{it} \tag{24}$$

and

$$\lambda^2 = \frac{\sigma_v^2}{\sigma_u^2} \geqq 0 \tag{25}$$

If $\lambda = 0$,there are no technical inefficiency effects and all deviations from the frontier are due to noise. Using this parameterization, the log – likelihood function is:

$$\ln L(\mathbf{y} \mid \boldsymbol{\beta}, \boldsymbol{\sigma}, \boldsymbol{\lambda}) = -\frac{1}{2}\ln\left(\frac{\pi\sigma^2}{2}\right) + \sum_{i=1}^{I} \ln\Phi\left(\frac{\epsilon_{it}\lambda}{\sigma}\right) - \frac{1}{2\sigma^2}\sum_{i=1}^{I}\varepsilon_{it}^2 \tag{26}$$

where $\mathbf{y}$ is a vector of log – outputs, $\epsilon_{it} = v_{it} - u_{it}$ is the composite error term and $\Phi(\mathbf{x})$ is the cumulative distribution function of the standard normal random variable evaluated at $\mathbf{x}$.

Maximizing a log – likelihood function usually involves taking first – derivatives with respect to the unknown parameters and setting them to zero. However, since these first – order conditions are highly nonlinear and cannot be solved analytically for $\boldsymbol{\beta}, \boldsymbol{\sigma}$,and $\boldsymbol{\lambda}$,we maximize the likelihood function using an iterative optimization procedure. This involves selecting starting values for the unknown parameters and systematically updating them until the values that maximize the log – likelihood function are found. In this case, the stochastic model is given by the equation:

$$\ln q_{it} = x_{it}\beta + v_{it} - u_{it},\; i = 1, 2, 3, ...I \tag{27}$$

along with (v_{it}) ˜$iidN(0,\, \sigma_v^2)$ and (u_{it}) ˜$iidN(0,\, \sigma_u^2)$.The parameters of the model take the form of x_{it} and β, with:

$$x_i = \begin{bmatrix} 1 \\ t_i \\ \ln x_{1i} \\ \ln x_{2i} \\ \ln x_{3i} \\ 0.5(\ln x_{1i})^2 \\ \ln x_{1i}\ln x_{2i} \\ \ln x_{1i}\ln x_{3i} \\ 0.5(\ln x_{2i})^2 \\ \ln x_{2i}\ln x_{3i} \\ 0.5(\ln x_{3i})^2 \end{bmatrix} \quad \text{and}$$

$$\beta = \begin{bmatrix} \beta_0 & \theta & \beta_1 & \beta_2 & \beta_3 & \beta_{11} & \beta_{12} & \beta_{13} & \beta_{22} & \beta_{23} & \beta_{33} \end{bmatrix}$$

where t_i is a time trend included to account for technological change. Technological advances often cause production functions to change over time, reflecting the industry - specific knowledge of technological developments and how they affect economic behavior within the industry.

In the case of the half – normal and exponential models, the null hypothesis is a single restriction involving a single parameter. If the model has been estimated using the method of *M.L.*, we can test such an hypothesis using a z-test (because unconstrained *M.L.* estimators are asymptotically normally distributed). In the half – normal model, the null and alternative hypotheses are $H_0 : \sigma_u^2 = 0$ and $H_1 : \sigma_u^2 > 0$. In the case of half – normal model hypothesis, if the test statistic z exceeds the critical value (regarding the specified level of significance), so we reject the null hypothesis that there are no inefficient effects (at the specified (%) level of significance). According to the parameterization of Aigner, Lovell and Schmidt (1977), the hypotheses become $H_0 : \lambda = 0$ and $H_1 : \lambda > 0$. In this parameterization, the test statistic is:

$$z = \frac{\hat{\lambda}}{se(\hat{\lambda})} \tilde{} N(0,1) \tag{28}$$

where $\hat{\lambda}$ is the maximum likelihood estimator of λ and $se(\hat{\lambda})$ is the estimator for its standard error.

However, in the literature, apart from the half - normal distribution (Aigner et al., 1977), there are several variations of the model allowing for different distributions of the terms v and u, such as truncated distributions, exponential distributions, or two - parameters gamma distributions (Kalirajan and Shand, 1999). Therefore, it is not uncommon to replace the half- normality assumption $(u_{it})\ \tilde{}\ iidN(0,\ \sigma_u^2)$ with one of the following assumptions:

1. model where the inefficiency disturbance is specified as a truncated (at 0) normal distribution: $(u_{it})\ \tilde{}\ iidN(\mu,\ \sigma_u^2)$, as described by Stevenson (1980).

2. model where the inefficiency disturbance is specified as an exponential distribution with mean λ: $(u_{it})\ \tilde{}\ iidG(\lambda,\ 0)$, as described by Meeusen and van den Broeck (1977)

3. model where the inefficiency disturbance is specified as a gamma distribution with mean λ and degrees of freedom m: $(u_{it})\ \tilde{}\ iidG(\lambda, m)$, as described by Greene (1990).

Normal, half normal and exponential distributions are arbitrary choices due to lack of a priori justification for selecting a particular distributional form for the technical inefficiency effects. The choice of distributional specification is sometimes a matter of computational convenience, since estimation of some frontier models is automated in some software packages, rather than others[5]. To give a general idea regarding these extensions, Nevertheless, even though the original stochastic frontier production function has been extended, the vast majority of applied papers involve the estimation of a single equation half – normal stochastic frontier, in which the model is expressed as the output of a firm as a function of its inputs plus a compound error (inefficiency and random terms) to test the null hypothesis that there is no technical inefficiency in the industry (Coelli et al., 2005).

5 Case - study: Public capital efficiency

In modern economic world, economic growth rate varies enormously among countries. The explanation of these differences in economic performance may be one important contribution to public and private policies towards efficiency and growth enhancement. The first step towards this is to decompose growth into its main components. Economic growth can be decomposed into two main components: increases in factor inputs (capital accumulation) and improvements in productivity. The first component attributes growth differences to differences in physical resources, physical capital, and labour. Notwithstanding, reducing differences in factor inputs is not sufficient to guarantee a proportional reduction in economic performance differences. The main reason is that productivity differences, the second component, may also play a determinant role in economic growth. Increases in productivity may be achieved through technical change (shifts on the production frontier) and through reductions in production inefficiency (movements towards the frontier).

In order to estimate the inefficiency effect, we apply a stochastic frontier approach to estimate technical efficiency using a Cobb - Douglas production function, incorporating inputs in terms of labor, private capital and public capital, in a case - study with real economic data.

Economic literature regarding estimation of public capital productive efficiency was initiated by Aschauer (1989)[6]. More specifically, Aschauer (1989) was the first economist who clearly expanded the general production function to include public capital as an additional input, using a Cobb - Douglas production function form. The central point of the analysis is a production function which incorporates the stock of public capital a time t, G_t, as an input in the production process. The production function becomes:

$$q_t = A_t\ f\ [K_t, G_t, L_t] \tag{29}$$

or

$$q_t = A_t K_t^{\alpha} G_t^{\beta} L_t^{\gamma}, \quad \alpha, \beta, \gamma > 0 \tag{30}$$

Taking natural logarithms on both sizes of , we get a linear function:

[6] Before Aschauer (1989), there were also researchers who included public capital as a factor of production, along with labor and private capital, such as Mera (1973), Ratner (1983) and Biehl (1986), even though in a broad way.

$$\ln q_t = \ln A_t + \alpha \ln K_t + \beta \ln G_t + \gamma \ln L_t \tag{31}$$

where:

1. q_t is the real aggregate output within some area (region or country)
2. A_t is an index of economy - wide productivity, representing the level of technology (Hicks - neutral technological progress)
3. K_t denotes the stock of (non - residential) private fixed capital
4. L_t denotes employment (measured by total hours worked, or numbers of employees)
5. $\alpha = \frac{d \ln q_t}{d \ln K_t}$ is the elasticity of output with respect to private capital
6. $\beta = \frac{d \ln q_t}{d \ln G_t}$ is the elasticity of output with respect to public capital
7. $\gamma = \frac{d \ln q_t}{d \ln L_t}$ is the elasticity of output with respect to labor

In the analysis of public capital efficiency, Aschauer (1989) has been the first to include public capital into the production function, as one of the inputs, along with private capital and employment. Since then, in general terms, the same approach has been used in the majority of public capital efficiency analysis research. Munell (1990) and more recent approaches, such as, Mamatzakis (2003) and Ligthart and Suarez (2005) followed the same method, considering public capital as an input in a neoclassical production model.

Aschauer (1989) concluded that more infrastructure can improve the productivity and also attract new establishments in a specific market or industry. This argument was also extended by Biehl (1986) and Seitz and Licht (1995), who investigated the influence of public capital in the formation of private investments, finding a significantly positive effect. Furthermore, researchers on economic growth such as Krugman (1991), Fujita et al. (1999) and Venables (1999) relate public capital investments to market access, transportation costs, technological externalities and agglomeration economies, all sources of accelerating growth. Their main argument is that the positive and scale externalities related to public capital investments are generated by inter-industry links and stimulated by the improvements in the access to consumers market, reduction of the cost of transactions, facilitation of the access to specialized services, availability of infrastructure, like telecommunication and transport, and spillovers of knowledge.

According to Aschauer (1989), public investment refers to expanding and improving the stock of infrastructure in roads, airports, water and sewage facilities, public transport and other utilities. Aschauer (1989) considered public capital to include transport infrastructure, electrical and gas facilities, water systems and sewers and any other public investments. This investment increases the productivity of private capital, making private investment more profitable and accelerating economic growth[7]. In this study, due to certain data availability and for simplicity reasons, we will estimate a time - series stochastic frontier model considering the public capital efficiency in Greek economy.

6 Methodology

As broadly analysed above, stochastic frontier analysis examines the relationship between output and input levels, using two error terms. One error term is the traditional normal error term in which the mean is zero and the variance is constant. The other error term represents technical inefficiency and may be expressed as a half – normal, truncated normal, exponential, or two – parameter gamma distribution. Technical efficiency is subsequently estimated via maximum likelihood estimation of the production function subject to the two error terms. Within this framework, we attempt to implement this method and estimate the impact of private and public capital on economic growth at the national level using time - series data. To estimate the parameters of the production function and the parameters in the equation of the expected inefficiency, we use a time - series single – stage model to investigate the inefficiency effects in stochastic production frontiers, applying the Maximum Likelihood method proposed by Kumbhakar et al. (1991), Reifschneider and Stevenson (1991) and Battese and Coelli (1995). The study follows the general research idea that stochastic production frontier model allows: a) technical inefficiency and input elasticities to vary over time in order to detect changes in the production structure, and b) inefficiency effects to be a function of a set of explanatory variables the parameters of which are estimated simultaneously with the stochastic frontier.

Efficiency is measured by separating the efficiency component from the overall error term. Economy may be off frontier because it is inefficient or because of random shocks or measurement errors. The model uses real GDP as the output and total employment, private capital and public capital as inputs. The model allows inefficiency to vary over time, and inefficiency effects to be a function of the level and composition of investment capital, private and public. As in Puig – Junoy (2001), we consider the sum of all individual production units as a single production unit and we assume away differences between firms within each national industry.

We assume a translog Cobb – Douglas production frontier function for Greek economy, covering years 1960 – 2001, with a data set of 42 annual observations. The data set is a time - series and the distribution chosen for the inefficiency component is the half – normal production. The estimation of the stochastic frontier is applied using the Maximum Likelihood (*M.L.*) method. With *M.L.*

[7] The same approach is followed by recent recearch. See for example, Benos and Karagiannis (2008), who specified public capital as the tangible capital stock owned by the public sector, excluding military structures and equipment. More specifically, they also considered public capital to include investments in roads, railways, airports, and utilities such as sewerage and water facilities, hospitals, educational buildings, and the rest of public investment.

estimation, we choose parameters so as to maximize probability that observed sample of data is generated by a hypothesized process. Finally, we test the inefficiency hypothesis.

The analysis presented below is carried out using LIMDEP (Econometric Software). LIMDEP computes parameter estimates for the single equation variants of the stochastic frontier model. The log-likelihood functions for these models must be maximized using iterative optimization routines.

7 Data description

The application implements a stochastic frontier analysis based on real data from the Greek economy as case - study. The public sector comprises the general government and non-financial public corporations, such as public administration and defense services, compulsory social security services, public administration, educational services, and health care and social assistance, provided by the government (no private provision included) plus investment in infrastructure provided by public organizations[8].

The data were extracted by the OECD Analytical database and the National Statistical Service of Greece. *Monetary values are evaluated at billions of national currency at 1995 prices. Total employment is evaluated at number of employees. Variables considered are expressed in the logarithmic form.*

8 Model Application

According to methodology described above, we consider a Cobb - Douglas stochastic frontier production function, in the form:

$$q_t = A_t \; f \; [K_t, G_t, L_t] \times \exp(v_{it}) \times \exp(-u_{it}) \tag{32}$$

As in the case study by Coelli et al. (2005), for simplicity reasons, we will also use three inputs (private capital stock, public capital stock, labor). Apart from these three inputs, we additionally use a constant term, as well as a time variable, in order to include any technological change effects on production process. We transform the model variables, set as the natural logarithms (ln) of the initial variables and we estimate the model, under the assumption it is a half - normal frontier. In the following step, via LIMDEP software program, we completed a number of iterations in order to estimate the half – normal frontier model through Maximum Likelihood estimation.

As far as the hypothesis testing is concerned, the usual test in the analysis of stochastic frontiers is testing for the absence of inefficiency effects. As stated before, in the case of the half – normal models, the null hypothesis is a single restriction involving a single parameter. Since our model has been estimated using the method of Maximum Likelihood, we can test such an hypothesis using the simple z-test.

[8] The same definition regarding public sector capital is also followed by Kamps (2004).

In the half – normal model, the null and alternative hypotheses are:

1. Null - Hypothesis: $H_0 : \sigma_u^2 = 0$ (meaning that there are in inefficiency effects), and

2. Alternative - Hypothesis: $H_1 : \sigma_u^2 > 0$ (meaning that there are inefficiency effects).

Following the parameterization of Aigner, Lovell and Schmidt (1977), the hypotheses of the model become $H_0 : \lambda = 0$ and $H_1 : \lambda > 0$, respectively.

The values $\hat{\lambda}$ is estimated by the model to be 4.102 (the maximum likelihood estimator of λ) and the value $se(\hat{\lambda})$ is estimated by the model to be 4.290 (estimator for the standard error of the maximum likelihood estimator of λ). In this model parameterization, the test statistic $z = \frac{\hat{\lambda}}{se(\hat{\lambda})}\tilde{\ }N(0,1)$ becomes $z = \frac{4.102}{4.290} = 0.956$.

In the case of half – normal model hypothesis testing, the test statistic $z = 0.956$ is less than the critical value of $z_{0.95} = 1.645$, (level of significance 95%), so we cannot reject the null hypothesis that there are no inefficient effects. Therefore, we assume that all the efficiency deviations from the stochastic frontier are due to measurement errors and effects beyond the control of the producers (in this case - study, the economy). The following step is to divide public capital stock into different spending priorities, in order to estimate the particular efficiency of each one of these in public capital efficiency level.

9 Conclusion

The study was primarily motivated by the idea that deviations from the production frontier may not be entirely under the control of the production unit itself. As Kumbhakar and Lovell (2000:72) indicated, "the great virtue of stochastic production frontier models is that the impact on output of shocks due to variation in labor and machinery performance, vagaries of the weather, and just plain luck can at least in principle be separated from the contribution of variation in technical efficiency".

Within this framework, measuring efficiency and productivity is a quite important task in economic analysis. First only by measuring efficiency and productivity, and by separating their effects from those of the general economic environment, can we explore hypotheses concerning the sources of efficiency or productivity differentials, as well as effectiveness of private practices and public policies designed to improve productive performance. Furthermore, efficiency and productivity measures are success indictors, by which producers are evaluated, so for the most efficient measurers to be taken.since productivity growth leads to improved economic and financial performance. Moreover, macro performance depends on micro performance and so the same reasoning applies to the study of the growth of nations (Lewis, 2004).

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“Econometric Analysis of realized Volatility: Evidence of Financial Crisis”

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Abstract. Financial series such as stock returns follow a different generating process from the relevant economic series. The key different between each other is that financial time series have some key features which cannot be captured by models such as ARMA. ARMA, which is referred as *autoregressive moving-average,* models consist a good approximation for economic series but not for financial series. In order to estimate financial time series we use the ARCH, *autoregressive conditional heteroskedasticity*, and GARCH, *generalized autoregressive conditional heteroskedasticity*, models. Moreover, we use six years data for four US stock indices such as, Dow Jones, NASDAQ, NYSE and S&P500, in order to analyse the volatility clustering and leverage effect. We conclude that the best fitted model for all our data is the EGARCH(1,1) in compare with an ARCH(6) or ARCH(4) and a GARCH(1,1). Additionally, we observed that the time periods between (28/07/2002-01/08/2003) and (11/08/2007-28/07/2008) are characterized by high volatility for all our series. In conclusion, we formulate and estimate multivariate volatility models, such as DVEC(1, 1), in order to show how the markets are linked by each other’s through time-varying covariance coefficients. The above methodology helps us to examine how the markets interact under the persistent of volatility effect. We use six years daily data from (26/3/2003) to (26/3/2009) in order to examine these interactions in S&P500, FTSE100 and DAX stock market indexes.

Keywords. Volatility; risk; ARCH; GARCH; EGARCH; Multivariate time series process.

1. INTRODUCTION

Financial world is based on the interaction between risk and returns. An investor must take some risks in order to achieve some level of wealth (rewards), but the general relationship between risk and rewards are not strictly analogy. Both risk and returns are in the future, so there is an expectation of loss a proportion of returns in balance with the risk that are taken. Financial econometricians express the exact relationship between risk and return as those risks which are calculated by the variance of the asset returns. It has been observed that volatility is not constant but it is changed over time, so it is larger for some period of time and smaller in other period of time. A standard approach in order to estimate the volatility is simply the sample standard deviation of returns in a time period, which called historical volatility. The main warning here is about the period of time. If we choose a short period of time for our sample of data we will get noisy results and if we select a long time horizon we will get results which will not be so relevant for resent measurements. So, historical volatility is not so reliable for further estimations and predictions. We need dynamic volatility models which will take the problem (warning) of time-varying volatility as a volatility that can be measured and not as a problem that must be corrected. Those models are the basic ARCH and GARCH models, which stand for *autoregressive conditional heteroskedasticity* and *generalized autoregressive conditional heteroskedasticity* and they were introduced by Engle (1982) and Bollerslev (1986) respectively.

Engle, R. (2007) argued that volatility is a fundamental factor in the global financial market. It is related with the risk that can be taken in order to have rewards. Risk and rewards are correlated each other but it is necessary to have a certain optimal behaviour in order to take risk, which can perform positive returns. So we choose a portfolio optimization position witch minimize the risk and maximize the rewards. Risk is determined by the variance of a portfolio in Markowitz (1952) theory for optimization. The same relationship between returns and variance can be sown in CAMP financial model which is introduced by Sharpe (1954). Moreover, risk can be determined very well by Black and Scholes (1972) model which is used in order to estimate the value of options in financial derivatives. The square route of variance is called volatility. Volatility is the standard deviation of the stock returns in a period of time. It is changing over time as it is presented by the analysts. We have different values of volatility in different time periods. Two basic types of volatility is the historical volatility and news volatility. The last is based on the element of information because every investor or risk manager would like to know if a small company will be developed in the future or not. Big companies give small volatility in contrast with small companies which give high volatility. So, if somebody knows that in a short period of time a company that is already small will be developed then he can arrange his investments in order to have arbitrage opportunities. Historical volatility, which is widely used, is estimated by historical data and it equals to the standard deviation of stock returns in a period of time. But if we get a short number of observations we will get noisy results and if we take a long series we will get smooth results which are not responding to the recent information. Historical volatility does not respond to that situation. ARCH models with their extensions come to fill this gap. ARCH (Autoregressive Conditional Heteroskedasticity) is introduced by Robert Engle in 1982 who won the Nobel price about that in 2003. ARCH volatility gives weights between the recent data and the data which are provided by information that happen a long time ago. The special feature of ARCH model is that it can calculate these weights based on historical data. There are lot extensions of ARCH models which describe non-linearity, asymmetry and long memory properties of volatility.

Dubofsky, D *et al*. (2003) argued that it is relevant to take the price of a call option as given and to formulate the variance of that option price. This variance or standard deviation is also referred as implied volatility (IV).

This article is organized as follows. In section 2, we introduce the formation of the fundamental volatility models which help us to examine the volatility clustering effect before and during the current financial crisis. In section 3, we give a description of our data and methodology in order to estimate the volatility processes which are analysed in the previous section. Finally, in section 4, we summarize the main findings.

2. FORMATION OF FUNDAMENTAL VOLATILITY PROCESSES

Let G be a subset of $\mathcal{R}$ ($G \subset \mathcal{R}$). Then $\forall t \in G$, the variable $x_t(p)$ is a random variable (rv) which is defined in a probability space $\wp$ ($\wp: p \in \wp$). Then, a stochastic process $\{x_t(p): \forall t \in G\}$ is referred as time series. If the elements of G are measured in discrete intervals then the time series process is a discrete time series, otherwise it is a continuous time series process with $t \in [0, \infty)$. Generally a stochastic process can be characterized by its conditional distribution. If the distribution function of (n) variables are time independent then the data generating process is called *strictly stationary*. The previous assumption is not very practical as well as it is quite general in order to deal with it. So, we consider that it is remarkable to check the stationarity assumption only on some moments of the distribution function. If the mean, variance and covariance of a stochastic process are time independent then the time series model is characterized as covariance stationary or weakly stationary.

Another issue which is necessary to be clear, before we continue our analysis of financial time series, is the concept of linearity. Campbell, Lo, and MacKinlay (1997) define the linearity in a suitable way and also they underline an excellent structure of a time series model, which based on a Taylor series analysis, in order to show how a nonlinear stochastic process is formulated. Based on them, a general structure of a stochastic process is given by the following form:

$$Y_t = f(u_t, u_{t-1}, u_{t-2}, \dots) \qquad \text{(I)}$$

If we expand the (I) in a Taylor series around a point ($u_t = 0$) conditional on the information set ($\Im_{t-1}: u_{t-i}, \forall i = 1, 2, \dots$), we take the following parameterisation of (I):

$$Y_t = g(u_{t-1}, u_{t-2}, \dots) + u_t l(u_{t-1}, u_{t-2}, \dots) \qquad \text{(II)}$$

$$E_{t-1}(Y_t) = g(u_{t-1}, u_{t-2}, \dots) \qquad \text{(III)}$$

$$E_{t-1}\left[\left(Y_t - E_{t-1}(Y_t)\right)^2\right] = l(u_{t-1}, u_{t-2}, \dots)^2 \qquad \text{(IV)}$$

We can see clearly from (III) and (IV) that models with nonlinear $g(.)$ can be referred as *nonlinear in mean* and times series processes with nonlinear functions $l(.)^2$ are called *nonlinear in variance*. Basically, the financial time series models are all nonlinear in variance or nonlinear both in variance and in mean. These models can capture the so called volatility clustering effect.

Generally, a financial analyst tries to approximate the relation between risk and return by using econometrics techniques for conditional variance which changes over time. This phenomenon is known as hetoroskedasticity. This effect may give bias estimates for a sample of data and also affects the efficiency of statistical inference about the estimated coefficients of a relevant time series model. It is quite important to consider the dynamic variance as a factor that we have to deal with rather than a problem for our models. The first model which has this property is introduced by Engle (1982)[1] and it is referred as ARCH (Autoregressive Conditional Heteroskedasticity). Moreover, there are a lot of extensions of ARCH that appeared in the relevant literature such as, ARCH-M, GARCH, EGARCH, TGARCH, GJR, AARCH, APARCH, FIGARCH, FIEGARCH, STARCH, SWARCH, GJR-GARCH, TARCH, MARCH, NARCH,SNPARCH, STUDENT-t-ARCH, but we focus only the mostly used symmetric models, ARCH, GARCH(1,1), ARCH-M and the most used asymmetric models, EGARCH and GJR which capture the asymmetric effects such as the leverage effect.

I. *Univariate case*

2.1 *Autoregressive Conditional Heteroskedasticity (ARCH)*

Let us suppose that our data are generated by an AR(p) process.

$$Y_t = \rho_0 + \rho_1 Y_{t-1} + \cdots + \rho_p Y_{t-p} + \varepsilon_t, \quad \varepsilon_t \sim N(0, \sigma^2) \qquad (2.1.1)$$

With $\sum_{i=1}^{p} \rho_i < 1$.

Since the unconditional mean of the above model is constant, there is not any useful meaning to use it in order to make forecasts. The optimal forecast for the (2.1.1) is given by the conditional mean of (2.1) which is given by:

$$E(Y_t / Q_t) = \rho_0 + \rho_1 Y_{t-1} + \cdots + \rho_p Y_{t-p} \quad (2.2)$$

Which Q_t represents the information set of our series, Y_t.

The (2.2) represents the linear forecast of the mean of our series, but also we would like to find a process which forecasts the variance of the model.

We know that the residuals in (2.1) are white-noise, which means that the unconditional variance is constant and equals by σ^2. The whole story is described by the unconditional variance of the errors, which may change over time. Let us suppose that the squares of errors are separately described by an AR(k) series such as below.

$$\varepsilon_t^2 = b_0 + b_1 \varepsilon_{t-1}^2 + \cdots + b_k \varepsilon_{t-k}^2 + u_t \qquad (2.3)$$

[1] Engle, R. (1982), "Autoregressive Conditional Heteroskedasticity with Estimates of theVariance of U.K. Inflation," *Econometrica*, 50, 987–1008.

Where u_t is white-noise variables:

$E(u_t) = 0 \; and \; E(u_t u_{t-j}) = \sigma^2 \; \forall j = 0 \; or \; zero \; otherwise.$

As the equation (2.1), the linear forecast for (2.3) is given by the conditional mean such as:

$$E(\varepsilon_t^2 / Q_t) = b_0 + b_1 \varepsilon_{t-1}^2 + \cdots + b_k \varepsilon_{t-k}^2 \qquad (2.4)$$

Where the information set, Q_t, includes that all the lagged values of ε_t^2: $Q_t = \{\varepsilon_{t-1}^2, \dots, \varepsilon_{t-k}^2\}$.

Any representation such as (2.3) for every white-noise process is called an *autoregressive conditional heteroskedastic process of order k* [ARCH(k)].

We see that the conditional variance of ε_t^2 is changed over time but the unconditional variance is constant and is given by:

$$\sigma^2 = E(\varepsilon_t^2) = \frac{b_0}{1 - b_1 - \cdots - b_k}$$

It is necessary to put some restrictions in our equations for conditional variance, in order to secure the possessiveness of volatility as any different result will be out of any meaning. So, this can be described by supposing that (2.4) is nonnegative and (2.3) is positive for every observation of ε_t. In order to take this result, we suppose that $b_i > 0 \; \forall i = 1,2, \dots, k$.

The equation (2.3) is stationary if $\sum_{i=1}^{k} b_i < 1$.

An ARCH model has many representations since the errors can be appeared in many different models such as an autoregression, an ARMA and the standard regression model. Basically, a linear representation such as (2.3) is not the most efficient since the model (2.1) and the models for the conditional variance are best estimated by MLE. So, a different approach is to represent the ε_t as:

$$\varepsilon_t = \sqrt{h_t} \cdot z_t \quad (2.5)$$

With z_t is an *(iid)* process with zero mean and unity variance as while h_t is described by:

$$h_t = b_o + b_1 \varepsilon_{t-1}^2 + \cdots + b_k \varepsilon_{t-k}^2 \quad (2.6)$$

If any white-noise process is generated by the equations (2.5) and (2.6) then it is an ARCH of order *k.* Additionally, any linear forecast of (2.5) follows the same equations as (2.3) which is the conditional mean as represented by (2.4).

2.2 *Estimation of ARCH*

We can estimate an ARCH model by using MLE techniques. In order to explain how we can do this theoretically, we suppose that we have to estimate a regression model with ARCH disturbances such as: $Y_t = a_1 X_{1t} + \varepsilon_t \quad (2.7)$

The disturbances follow the ARCH conditions of equations (2.5) and (2.6). Again we suppose that we have an information set, Q_t, which includes all the lagged values of (Y_t, X_{1t}). With the above assumptions we conclude that the probability distribution for Y_t is given by:

$$f(Y_t/X_{1t}, Q_t) = \frac{1}{\sqrt{2\pi h_t}} exp\left[\frac{-(Y_t - a_1 X_{1t})^2}{2h_t}\right] \qquad (2.8)$$

Where, $h_t = b_o + b_1 \varepsilon_{t-1}^2$. The term ε_{t-1}^2 equals the expression $(Y_{t-1} - a_1 X_{1t})^2$.

Our data vector is given by $\boldsymbol{\delta} = (a_1, b_o, b_1)$. We have to maximize the log likelihood function which given by,

$$\mathfrak{L}(\boldsymbol{\delta}) = \sum_{t=1}^{T} \log f(Y_t/X_{1t}, Q_t, \boldsymbol{\delta}) = -\frac{T}{2}\log(2\pi) - \frac{1}{2}\sum_{t=1}^{T}\log(h_t) - \frac{1}{2}\sum_{t=1}^{T}\frac{\varepsilon_t^2}{h_t} \qquad (2.9)$$

2.3 *Test for ARCH*

Engle (1982) proposed a test for the time-varying variance (heteroskedasticity). This test involves some steps.

Step1: we estimate the regression model such as (2.7) by OLS by ignoring the hetereoskedasticity.

Step2: obtain the residuals from the above regression and store it in our database.

Step3: we regress the squares residuals, ε_t^2, on a constant and *k* of its own lagged values. If there are ARCH effects then the coefficients of lagged errors values must be insignificant from zero.

In model such as, $\varepsilon_t^2 = b_0 + b_1 \varepsilon_{t-1}^2 + \cdots + b_m \varepsilon_{t-k}^2 + u_t$, the estimated values of $(b_1, \ldots, b_k)$ must be other than zero.

If we conclude that there are ARCH effects then the coefficient of determination of the above model must be quite high. Under the null of no ARCH effect the test statistic, TR^2, follows a x^2distribution. Here the T represents the magnitude of a sample of residuals and the R^2 the coefficient of determination. If the test statistic is sufficient low we conclude that there no ARCH effects and if the test statistic is high we conclude that there are ARCH effects.

2.4 *Extensions of ARCH*

GARCH:

The most widely used extension of ARCH is the GARCH model which is introduced by Bollerslev (1986)[2]. GARCH stands for *generalized autoregressive conditional heteroskedasticity*.

[2] Bollerslev, T.P. (1986). "Generalized Autoregressive Conditional Heteroscedasticity", *Journal of Econometrics*,31:309-28.

Let us suppose that we have an ARCH specification for the residuals as:

$\varepsilon_t = \sqrt{h_t} \cdot z_t$

With

$h_t = b_o + b_1 \varepsilon_{t-1}^2 + \cdots + b_k \varepsilon_{t-k}^2$ and $z_t \sim iidN(0,1)$.

The above model for the conditional variance h_t can be rewritten as:

$h_t = b_0 + b_1 L^1 \varepsilon_t^2 + \cdots + b_k L^k \varepsilon_t^2 = b_0 + B(L)\varepsilon_t^2$

With $B(L) = b_1 L^1 + \cdots + b_k L^k$, represents the lag operator.

If we generalized the above lag operator as a ratio of two lag operators such as,

$A(L) = \frac{B(L)}{C(L)}, with\ C(L) = 1 - c_1 L^1 - \cdots - c_m L^m$

We conclude to a generalized representation of conditional variance as shown below.

$h_t = m + c_1 h_{t-1} + \cdots + c_m h_{t-m} + b_1 \varepsilon_{t-1}^2 + \cdots + b_k \varepsilon_{t-k}^2$ (2.10)

If a process ε_t is generated like (2.5) with a combination of (2.10) then we say that the ε_t is generated by a GARCH model, and we denote it like $\varepsilon_t \sim GARCH(m, k)$.

We can see that if the ARCH is generated by an AR representation then the GARCH is generated by an ARMA representation and the polynomial operator *A(L)* is exactly the same as we move from an AR to an ARMA model. Furthermore, we can estimate a GARCH by MLE with the same philosophy as an ARCH and we can test for GARCH with the same method as an ARCH.

IGARCH:

Another extension of ARCH is the IGARCH model. A GARCH(*m*,*k*) model is given by

$\varepsilon_t = \sqrt{h_t} \cdot z_t$ and

$h_t = m + c_1 h_{t-1} + \cdots + c_m h_{t-m} + b_1 \varepsilon_{t-1}^2 + \cdots + b_k \varepsilon_{t-k}^2$.

The above process for conditional variance has unite root (stationary process) if the following condition is satisfied:
$\sum_{i=1}^{m} c_i + \sum_{j=1}^{k} b_j = 1$ (2.11)

Any model which satisfies (2.5), (2.10) and (2.11) is referred as an *integrated GARCH model* and is denoted as IGARCH.

ARCH-M:

This model is introduced by Engle, Lilien and Robins (1987). We can say that it captures the relation between risk and return by considering that the mean of returns can be related with the variance of the returns. This relation is introduced by a regression model of the following form:

$$r_t = \mu_t + \theta h_t + \varepsilon_t \quad (2.12)$$

Where r_t is a series for returns, μ_t represents the mean of returns and the term (ε_t) satisfies the conditions (2.5) and (2.6). The coefficient (θ) capture the effect that higher risk, which is represented by the variance of ε_t, gives higher returns (r_t).

EGARCH:

This model is introduced by Nelson (1991) and it is useful because caprture some asymmetric effects which cannot be captured by the symmetric ARCH models like the above. The most interesting asymmetric effect is the leverage effect and it is related with the impact of news in volatility. More specifically, this effect is occurred when the volatility increases when actually the prices dropped (bad news) rather that when the prices are increased (good news) on similar level. The above effect cannot be explained by the ARCH and GARCH. So, Nelson (1991) proposed the following model for the conditional variance.

Let us suppose that the equation (2.5) is occurred. Then we have,

$$\left.\begin{aligned} &\varepsilon_t = \sqrt{h_t} \cdot z_t \\ &\text{and,} \\ &\log(h_t) = \delta + \sum_{i=1}^{\infty} \psi_i \{|z_{t-i}| - E(|z_{t-i}|) + \theta z_{t-i}\} \\ &\text{With } z_t \sim iidN(0,1). \end{aligned}\right\} \quad (2.13)$$

Any model with the characteristics of (2.13) is called *exponential* GARCH or EGARCH.

The asymmetric effect is expressed by the parameter (θ) in the (2.13). If $\theta = 0$ then any positive sock has the same magnitude on volatility with any negative sock. If $-1 < \theta < 0$ then a negative sock decreases volatility in a higher degree than any positive sock. When $\theta < -1$, any random negative sock increases the volatility while any positive random sock decreases the volatility.

<u>GJR:</u>

The GJR model also can capture the asymmetric effects of positive and negative random socks. GJR model for conditional variance is proposed by Glosten, Jagannathan and Runkle (1989) and can be described as following:

Again we suppose that

$$\left.\begin{aligned} &\varepsilon_t = \sqrt{h_t} \cdot z_t \text{ , with } z_t \sim iidN(0,1). \\ &\text{And} \\ &h_t = \delta + b_1 h_{t-1} + a_1 \varepsilon_{t-1}^2 + \theta \varepsilon_{t-1}^2 \cdot I_{t-1} \end{aligned}\right\} \quad (2.14)$$

In the above expression, the factor I_{t-1} is a dummy variable. If $\varepsilon_{t-1} \geq 0$ then $I_{t-1} = 1$ and 0 otherwise. If we find a negative estimation of (θ) then we expect to capture the leverage effect. Again we want the above expression for the variance to be positive. We can secure this if we put the restriction $(b_1 > 0 \; and \; a_1 + \theta > 0)$ for the parameters.

II. Multivariate case

Generally, it is observed that the markets are cointegrated each other which means that price movements of one market index can affect another market index. The fact of interrelated markets is a key factor in financial analysis and it can be captured statistically by multivariate time series models. Such models contain multiple return series of the cointegrated markets and the main propose is to analyse the effect of conditional covariance between them in order to examine the dynamic volatility processes among the multiple return series.

We consider that the returns of three stock indexes are modelled as the summation of a constant and the innovation of the series such as following:

$\boldsymbol{r_t} = \boldsymbol{\mu} + \boldsymbol{u_t}$ (2,15)

Where

$\boldsymbol{r}_t = (r_{1,t}, r_{2,t}, r_{3,t})', \boldsymbol{\mu} = (\mu_1, \mu_2, \mu_3)', \boldsymbol{u}_t = (u_{1,t}, u_{2,t}, u_{3,t})'$

The conditional covariance matrix of the innovation vector $\boldsymbol{u}_t$, given the information set $\beth_{T-1}$, is defined as $\boldsymbol{H}_t = Cov(\boldsymbol{u}_t \wr \beth_{T-1})$. We apply a diagonal VEC model (DVEC) to our series for the volatility modelling, which refers to the time varying of $\boldsymbol{H}_t$. The DVEC(p,q) is defined as:

$$\boldsymbol{H}_t = \boldsymbol{C} + \sum_{i=1}^{p} \boldsymbol{A}_i \odot \left(\boldsymbol{u_{t-i}}\boldsymbol{u'_{t-i}}\right) + \sum_{j=1}^{q} \boldsymbol{B}_j \odot \boldsymbol{H}_{t-j} \qquad (2, 16)$$

The (2, 16) is transformed to DVEC(1,1) as:

$$\boldsymbol{H}_t = \boldsymbol{C} + \boldsymbol{A} \odot \left(\boldsymbol{u_{t-1}}\boldsymbol{u'_{t-1}}\right) + \boldsymbol{B} \odot \boldsymbol{H}_{t-1} \qquad (2, 17)$$

$\boldsymbol{H}_t = \begin{bmatrix} h_{11,t} & \cdot & \cdot \\ h_{21,t} & h_{22,t} & \cdot \\ h_{31,t} & h_{32,t} & h_{33,t} \end{bmatrix}$ is the covariance matrix, where $h_{11,t}, h_{22,t}, h_{33,t}$ are the variance elements and the cross products are the covariance elements between each other. $h_{21,t}$ expresses the time varying correlation between the elements (2,1) at time *t*, $h_{31,t}$ expresses the time varying correlation between the elements (3,1) at time *t* and $h_{32,t}$ expresses the time varying correlation between (3,2) at time *t*.

Matrix **C** contains the constant terms and it is given by:

$\boldsymbol{C} = \begin{bmatrix} c_{11} & \cdot & \cdot \\ c_{21} & c_{22} & \cdot \\ c_{31} & c_{32} & c_{33} \end{bmatrix}$, moreover the symmetric matrices (**A, B**) are formatted as **C** and contain the constant ARCH and GARCH coefficients respectively.

Analytically, the (2, 17) is written as:

$$\begin{bmatrix} h_{11,t} & \cdot & \cdot \\ h_{21,t} & h_{22,t} & \cdot \\ h_{31,t} & h_{32,t} & h_{33,t} \end{bmatrix} =$$
$$\begin{bmatrix} c_{11} & \cdot & \cdot \\ c_{21} & c_{22} & \cdot \\ c_{31} & c_{32} & c_{33} \end{bmatrix} + \begin{bmatrix} a_{11} & \cdot & \cdot \\ a_{21} & a_{22} & \cdot \\ a_{31} & a_{32} & a_{33} \end{bmatrix} \odot \begin{bmatrix} u_{1,t-1}^2 & \cdot & \cdot \\ u_{1,t-1}u_{2,t-1} & u_{2,t-1}^2 & \cdot \\ u_{3,t-1}u_{1,t-1} & u_{3,t-1}u_{2,t-1} & u_{3,t-1}^2 \end{bmatrix} +$$
$$\begin{bmatrix} b_{11} & \cdot & \cdot \\ b_{21} & b_{22} & \cdot \\ b_{31} & b_{32} & b_{33} \end{bmatrix} \odot \begin{bmatrix} h_{11,t-1} & \cdot & \cdot \\ h_{21,t-1} & h_{22,t-1} & \cdot \\ h_{31,t-1} & h_{32,t-1} & h_{33,t-1} \end{bmatrix} \qquad (2, 18)$$

If we solve the above equation, we conclude to six equations which three of them are the conditional variance equations and the other three are the conditional covariance equations.

So,

- Variance equations

$$\begin{pmatrix} h_{11,t} = c_{11} + a_{11}u_{1,t-1}^2 + b_{11}h_{11,t-1} \\ h_{22,t} = c_{22} + a_{22}u_{2,t-1}^2 + b_{22}h_{22,t-1} \\ h_{33,t} = c_{33} + a_{33}u_{3,t-1}^2 + b_{33}h_{33,t-1} \end{pmatrix}$$

- Covariance equations

$$\begin{pmatrix} h_{21,t} = c_{21} + a_{21}u_{2,t-1}u_{1,t-1} + b_{21}h_{21,t-1} \\ h_{31,t} = c_{31} + a_{31}u_{3,t-1}u_{1,t-1} + b_{31}h_{31,t-1} \\ h_{32,t} = c_{32} + a_{32}u_{3,t-1}u_{2,t-1} + b_{32}h_{32,t-1} \end{pmatrix}$$

Another multivariate model, which is appeared in literature by Engle and kroner in 1995, is the BEKK model:

$$\boldsymbol{H}_t = \boldsymbol{C}\boldsymbol{C}' + \sum_{i=1}^{p} \boldsymbol{A}_i(\boldsymbol{u}_{t-i}\boldsymbol{u}_{t-i}')\boldsymbol{A}_i' + \sum_{j=1}^{q} \boldsymbol{B}_j \boldsymbol{H}_{t-j} \boldsymbol{B}_j'$$

where **C** is a lower triangular matrix and $(\boldsymbol{A}_i, \boldsymbol{B}_j)$ are square matrices. The main warning of the above model is that there are $\{K^2(p+q) + \frac{K(K+1)}{2}\}$ parameters to be estimated which is not practical when (p, q) are high.

Bollerslev (1990) proposed the constant-correlation model in order to deal with the above constrains (low estimated parameters and volatility equations). the main equation of this models is:

$$\boldsymbol{H}_t = \boldsymbol{C} + \sum_{i=1}^{p} \boldsymbol{a}_i \boldsymbol{a}_{t-i}^2 + \sum_{j=1}^{q} \boldsymbol{b}_j \boldsymbol{H}_{t-j}$$

Which in the case of GARCH(1,1) parameterisation is given by:

$$\boldsymbol{H}_t = \boldsymbol{C} + \boldsymbol{a}_1 \boldsymbol{a}_{t-1}^2 + \boldsymbol{b}_1 \boldsymbol{H}_{t-1}$$

The above multivariate volatility model is referred as constant conditional correlation (CCC) model and is the most efficient for large systems. It is easily estimated by two steps. The first step contains estimation of all univariate models and then (2nd step) calculation of the correlation between the standardize residuals. Moreover it contains easy likelihood functions for the estimated elements.

Engle (2002a) proposed a parameterisation of the CCC model by allowing the correlations to vary rather than to be constant over time (Dynamic conditional correlation-DCC- model). The technique of this model is to formulate the squared elements (volatilities) in one set and the cross products (correlations) in another set. So, the correlation elements can be modelled by DCC as a separate process from volatilities.

3. DATA ANALYSIS AND RESULTS

III. *Univariate case*

Generally, we are interesting in volatility modelling of the US stock index market. We chose to pick 6 years daily data prices in order to have a completed sequence for our series while the relevant literature mentions that in order to have clear and reliable time series we have to collect at least 4 years daily data. That is because daily series frequencies are more useful in contrast with weekly or monthly frequencies due to louse crucial information. Finally, we select to pick data from (28/7/2002) to (28/7/2008). These data are referred to closing prices of US stock indices. While we are interesting to model the volatility of these indices, we have to calculate the returns of that series in order to obtain the volatility clustering feature which is appeared by plotting the time series sequences of returns. We did not select the examining time period (28/7/2002-28/7/2008) randomly. We picked that time horizon for our analysis because we did not want to include the period of 2001 which was stigmatized by the terrorist attack in New York, while we know that every random sock affects our series in a bid level. The key feature of volatility clustering is that shows the periods in which the market can be characterized by low or high volatility. If the returns are shown to have large dispersion then this period of time can be characterized by high volatility in the market and if the returns are appeared to have low dispersion, this period of time can be characterized by low volatility in the market.

The prices and returns are determined as we have explained in the previous chapter. It is necessary to use an econometric model for our returns in order to capture the volatility clustering and the leverage effect. The basic econometric model for returns is the random walk model (RW) which is given by,

$$r_t = \delta + \varepsilon_t \qquad (1)$$

The term (δ) represents the mean value of returns. Another approach is to use an AR(1) model for our returns sequence such as:

$$r_t = \delta + \rho_1 r_{t-1} + \varepsilon_t \qquad (2)$$

The above models cannot explain accuracy the financial features of returns. The key reason is that the financial time series much be analysed under the assumptions of stylized facts of financial returns which have already analysed in the previous chapter. In order to model the volatility effects we need ARCH and GARCH processes which also are generated by models such as (1)&(2).

We are going to describe our series by an ARCH(6), GARCH(1,1) and EGARCH models. So, an ARCH(6) model for returns is given by the following equation:

$$\left.\begin{aligned} & r_t = \delta + \varepsilon_t \ , \\ & \varepsilon_t = \sqrt{h_t} \cdot z_t \\ & \text{and} \\ & h_t = w + p_1\varepsilon_{t-1}^2 + p_2\varepsilon_{t-2}^2 + p_3\varepsilon_{t-3}^2 + p_4\varepsilon_{t-4}^2 + p_5\varepsilon_{t-5}^2 + p_6\varepsilon_{t-6}^2 \ , z_t \sim iidN(0,1). \end{aligned}\right\} \quad (3)$$

Similarly, a GARCH(1,1) representation for returns is estimated as:

$$\left.\begin{aligned} & r_t = \delta + \varepsilon_t \ , \\ & \varepsilon_t = \sqrt{h_t} \cdot z_t \\ & \text{and} \\ & h_t = w + p_1\varepsilon_{t-1}^2 + b_1 \mathrm{h}_{t-1}, \ z_t \sim iidN(0,1) \end{aligned}\right\} \quad (4)$$

Finally, the EGARCH model for returns is captured as:

$$\left.\begin{aligned} & r_t = \delta + \varepsilon_t \ , \\ & \varepsilon_t = \sqrt{h_t} \cdot z_t \\ & \text{and} \\ & \log(h_t) = w + \textstyle\sum_{i=1}^{\infty} \psi_i \{|z_{t-i}| - E(|z_{t-i}|) + \theta z_{t-i}\}, z_t \sim iidN(0,1) \end{aligned}\right\} \quad (5)$$

We are going to base on the above models in order to analyse the results and moreover the volatility which is captured by them. We tested about ARCH effects with (3) but empirically we concluded that ARCH models with less lagged values of errors, such as ARCH(4), fitted better on some samples of data. In order to switch which model is better for a specific data set, e.g. Nyse, we based on the minimum AIC[3] criterion.

The results of each volatility model for our four US indices are shown by tables (1) to (4). The numbers inside the brackets indicate the p-value for each estimated parameter. Generally the stationary assumption is hold for all models which is what we expect.

Analytically, we estimated an ARCH(6), GARCH(1,1) and EGARCH(1,1) models for the Down Jones index returns from (28/07/2002) to (28/7/2008) time period and the results are presented by table (1). All ARCH and GARCH coefficients are shown to be positive and significant at 1% level of significance, except the first lag for ARCH(6) model. Moreover, the sum of ARCH and GARCH elements $(p_1 + b_1)$ for the GARCH(1,1) are quite close to unity (0.995984) which means that there are volatility sock effects in our series. The sum of ARCH and GARCH coefficients is very important because it shows the implication of a sock on returns, except that it is an indicator for the stationarity of our model. In order to understand the asymmetric effects, we can transform the EGARCH conditional variance for returns to the following form:

$$\ln(h_t) = \delta + p_1 \left|\frac{\varepsilon_{t-1}}{h_{t-1}}\right| + \theta \frac{\varepsilon_{t-1}}{h_{t-1}} + b_1 h_{t-1} \quad (6)$$

The asymmetric effect such as the leverage effect is captured by the parameter (θ). In this case the value of this parameter (-0.089691) is between (-1) and (0) and it is significant at 1% level of significance, which means that a negative surprise sock affects in higher degree the volatility in contrast with a positive surprise sock. A negative surprise sock could be characterised by an unexpected drop in price and a positive surprise sock could be characterized by an unexpected rise in price.

Table 1: Volatility models for Down Jones returns.

			DOWJONES			
	ARCH(6)		GARCH(1,1)		EGARCH(1,1)	
δ	0.000504659	(0.019)	0.00041973	(0.03)	0.000727822	(0)
w	2.60E-05	(0)	4.65E-07	(0.136)	0.00425087	(0.847)
p_1	0.0153726	(0.545)	0.0558836	(0)	0.102852	(0)
p_2	0.0909042	(0.009)				
p_3	0.101659	(0.002)				
p_4	0.195116	(0)				
p_5	0.215198	(0)				
p_6	0.128851	(0)				
b_1			0.9401	(0)	0.999787	(0)
θ					-0.089691	(0)
(α+β)<1			0.995984			
AIC	-6.66556871		-6.7227259		-6.75321211	

[3] AIC stands for **Akaike's information criterion** and is a measure of the goodness of fit of an estimated model. Generally, we choose that model, which has minimum AIC.

In order to choose the best model for Dow Jones data set, we based on the minimum AIC criterion. The most sufficient model is the EGARCH(1,1) with minimum value of (-6.75321211) in contrast with ARCH(6)-(-6.66556871) and GARCH(1,1)-(-6.7227259).

We follow the same analysis procedure for the NASDAQ index returns. The results are presented by table (2). We estimated an ARCH(6) model, because it has the minimum AIC in contrast with lower lagged ARCH models, a GARCH(1,1) and an EGARCH(1,1). We can see that all the ARCH and GARCH coefficients are positive and quite significant at 1% level of significance, except the first lagged value of the ARCH(6) model. Additionally, the sum of the ARCH and GARCH coefficients (0.998399) for the GARCH(1,1) model are below one and close to it which implies the stationarity of our model and moreover the persistence of volatility on our index's returns. Since the value of parameter that captures the asymmetric effect for the EGARCH model (-0.0616451) is between (-1) and (0) and significant at 1% level of significance, we conclude that bad news (negative shocks) increases the volatility more that the good news (positive shocks).

Table 2: Volatility models for NASDAQ returns.

			NASDAQ			
	ARCH(6)		GARCH(1,1)		EGARCH(1,1)	
δ	0.000721829	(0.007)	0.000451127	(0.088)	0.000773026	(0.006)
w	4.42E-05	(0)	4.16E-07	(0.308)	-0.00453534	(0.787)
p_1	5.79E-31	(1)	0.0389021	(0)	0.0681133	(0)
p_2	0.10831	(0)				
p_3	0.0972697	(0.001)				
p_4	0.195399	(0)				
p_5	0.184849	(0)				
p_6	0.157866	(0)				
b_1			0.959497	(0)	0.999182	(0)
θ					-0.0616451	(0)
(α+β)<1			0.998399			
AIC	-6.09742751		-6.13361795		-6.1525585	

As we can see from the above table, the most sufficient model for our data set is the EGARCH model because it has the minimum AIC value (-6.1525585) in contrast with the others.

Volatility effects of the Dow Jones and NASDAQ indices can be described by the same model (EGARCH) and they represent the same asymmetric effect by the same way. The same results we can see for the S&P 500 and NYSE indices. Analytically, we estimate an ARCH(4) model, because it has the minimum AIC value comparing with the lower lagged ARCH(6), a GARCH(1,1) and an EGARCH(1,1). The results are presented by tables (3), (4). Again all the ARCH and GARCH coefficients are significant at 1% level of significance, except the first lag coefficient for the ARCH(4) model, and positive which imply the volatility shock on returns. The sum of ARCH and GARCH coefficients (0.996397), (0.994254) for S&P 500 and NYSE are close to one respectively which what we expect to be for the GARCH models. The coefficient (θ) is between (-1) and (0) for both EGACRH models for both series and it implies the same asymmetric effect of that bad news increase the volatility more that good news.

Table 3: Volatility models for NYSE returns.

	NYSE					
	ARCH(4)		GARCH(1,1)		EGARCH(1,1)	
δ	0.000653191	(0.001)	0.000631922	(0.001)	-0.00093338	(0)
w	3.80E-05	(0)	6.43E-07	(0.092)	-0.0182625	(0.567)
p_1	0.0600785	(0.056)	0.0644086	(0)	0.12842	(0)
p_2	0.18258	(0)				
p_3	0.178883	(0)				
p_4	0.177397	(0)				
p_5						
p_6						
b_1			0.929846	(0)	0.997356	(0)
θ					-0.0882891	(0)
(α+β)<1			0.994254			
AIC	-6.60676951		-6.69108312		-6.71287146	

Table 4: Volatility models for S&P 500 returns.

	S&P500					
	ARCH(4)		GARCH(1,1)		EGARCH(1,1)	
δ	0.000540754	(0.011)	0.00045956	(0.021)	0.000800963	(0)
w	3.96E-05	(0)	4.77E-07	(0.147)	0.000355856	(0.987)
p_1	0.0323863	(0.2)	0.056831	(0)	0.0975266	(0)
p_2	0.154992	(0)				
p_3	0.193089	(0)				
p_4	0.224528	(0)				
p_5						
p_6						
b_1			0.939566	(0)	0.999291	(0)
θ					-0.0932241	(0)
(α+β)<1			0.996397			
AIC	-6.56198753		-6.6547951		-6.68866912	

The next figures present the returns and the volatility clustering for each of the following series (DOW Jones, NASDAQ, NYSE and S&P500) respectively. We can observe that when we have excess returns for the financial time series, the volatility is high and if we have flatter returns the volatility is low. This description gives the volatility clustering effect. Generally, the periods of high volatility for all indices observed at the beginning of our estimation period and at the end of our estimation period, thus for time periods during (28/07/2002-01/08/2003) and (11/08/2007-28/07/2008).

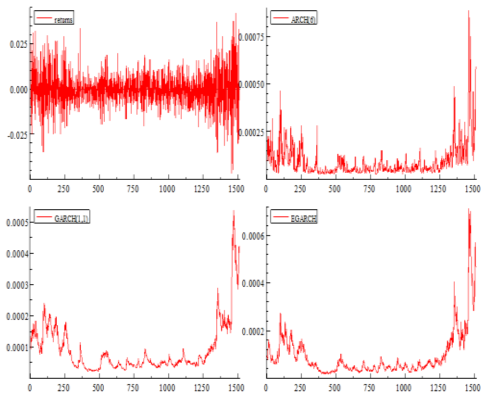


Figure 1: Dow Jones returns and volatility effects.

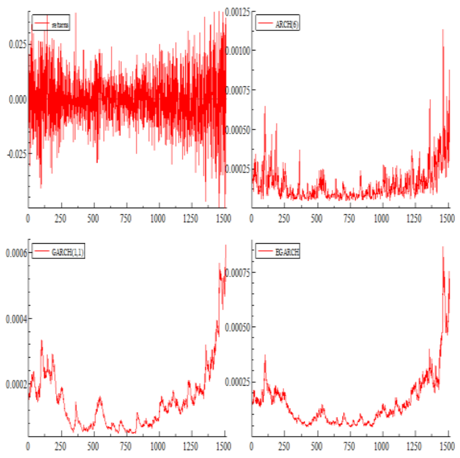


Figure 2: NASDAQ returns and volatility effects.

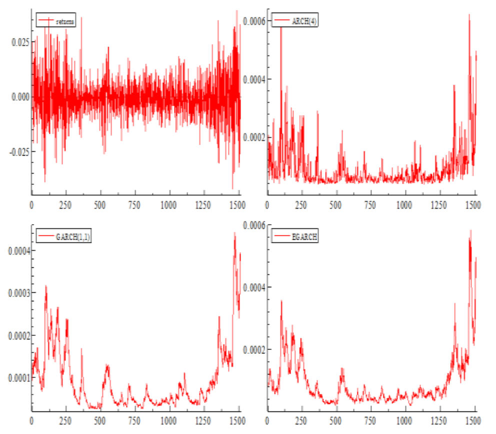


Figure 3: NYSE returns and volatility effects

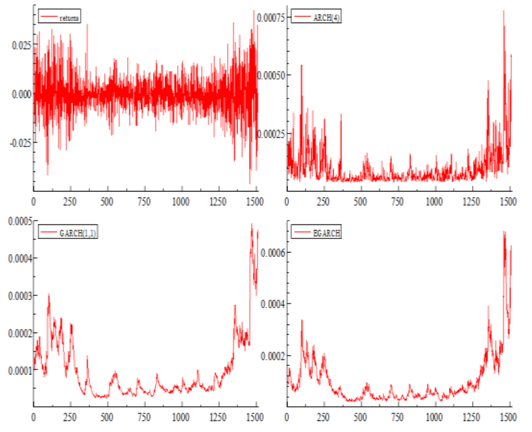


Figure 4: S&P500 returns and volatility effects.

IV. Multivariate case

We use six years daily data, (27/03/2003-27/03/2009), of three index markets in order to analyse the dynamic volatility process of the multiple returns series. The financial data are obtained by finance yahoo and they are referred to S&P500, FTSE100 and DAX indexes. We use the Eviews in order to estimate the DVEC(1,1) for multivariate volatility modelling. The results are as follows:

Mean return coefficients: $\boldsymbol{\mu} = (\mu_{DAX}, \mu_{SP}, \mu_{FTSE})'$

	Coefficient	Std. Error	z-Statistic	Prob.
μ_{DAX}	0.000424	0.000211	2.015391	0.0439
μ_{SP}	0.000951	0.000227	4.197419	0.0000
μ_{FTSE}	0.000402	0.000174	2.315334	0.0206

Variance equation coefficients : $\boldsymbol{H}_t = \boldsymbol{C} + \boldsymbol{A} \odot (\boldsymbol{u}_{t-1}\boldsymbol{u}'_{t-1}) + \boldsymbol{B} \odot \boldsymbol{H}_{t-1}$

	Coefficient	Std. Error	z-Statistic	Prob.
c_{11}	1.07E-06	2.57E-07	4.176144	0.0000
c_{21}	8.10E-09	8.75E-08	0.092494	0.9263
c_{31}	4.12E-08	1.19E-07	0.346709	0.7288
c_{22}	1.40E-06	4.09E-07	3.437896	0.0006
c_{32}	6.37E-07	1.71E-07	3.732300	0.0002
c_{33}	6.23E-07	2.62E-07	2.380411	0.0173
a_{11}	0.069628	0.010035	6.938250	0.0000
a_{21}	0.027091	0.008416	3.218940	0.0013
a_{31}	0.032508	0.010136	3.207150	0.0013
a_{22}	0.086118	0.008636	9.971709	0.0000
a_{32}	0.101354	0.008243	12.29530	0.0000
a_{33}	0.118790	0.010619	11.18611	0.0000
b_{11}	0.921071	0.011477	80.25359	0.0000
b_{21}	0.950562	0.015305	62.10840	0.0000
b_{31}	0.909211	0.034597	26.28006	0.0000
b_{22}	0.909612	0.009561	95.13774	0.0000
b_{32}	0.898372	0.007380	121.7372	0.0000
b_{33}	0.888821	0.009526	93.30626	0.0000

Table 1: Estimated *coefficients for mean return equation and DVEC(1,1)*

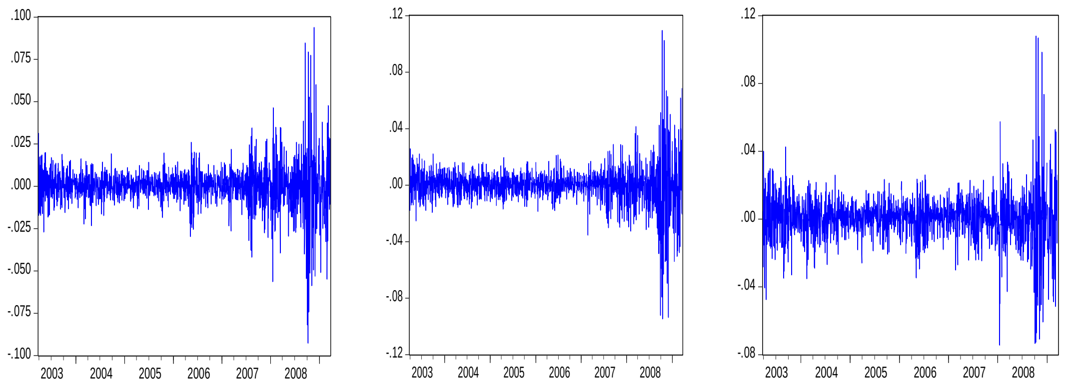
Based on the table 1, our equations about conditional variances and covariances are estimated as:

$$\begin{pmatrix} r_{DAX,t} = 0.000424 + u_{DAX,t} \\ r_{SP,t} = 0.000951 + u_{SP,t} \\ r_{FTSE,t} = 0.000402 + u_{FTSE,t} \end{pmatrix}$$

$$\begin{pmatrix} h_{11,t} = 1.07E-06 + 0.069628u_{1,t-1}^2 + 0.921071h_{11,t-1} \\ h_{22,t} = 1.40E-06 + 0.086118u_{2,t-1}^2 + 0.909612h_{22,t-1} \\ h_{33,t} = 6.23E-07 + 0.118790u_{3,t-1}^2 + 0.888821h_{33,t-1} \end{pmatrix}$$

$$\begin{pmatrix} h_{21,t} = 8.10E-09 + 0.027091u_{2,t-1}u_{1,t-1} + 0.950562h_{21,t-1} \\ h_{31,t} = 4.12E-08 + 0.032508u_{3,t-1}u_{1,t-1} + 0.909211h_{31,t-1} \\ h_{32,t} = 6.37E-07 + 0.101354u_{3,t-1}u_{2,t-1} + 0.898372h_{32,t-1} \end{pmatrix}$$

Figure 1 shows the time plot of returns for each series and figure 2 shows the estimated volatilities for continuously compounded returns for each index market. Moreover, figure 2 presents the time-varying correlations of DVEC(1,1) model for continuously compounded returns of the three index markets.



(a)Returns_FTSE100 (b) Returns_S&P500 (c) Returns_DAX

Figure1: Continuously compounded returns for series FTSE100, S&P500 and DAX. The time horizon is from (27/03/2003) to (27/03/2009).

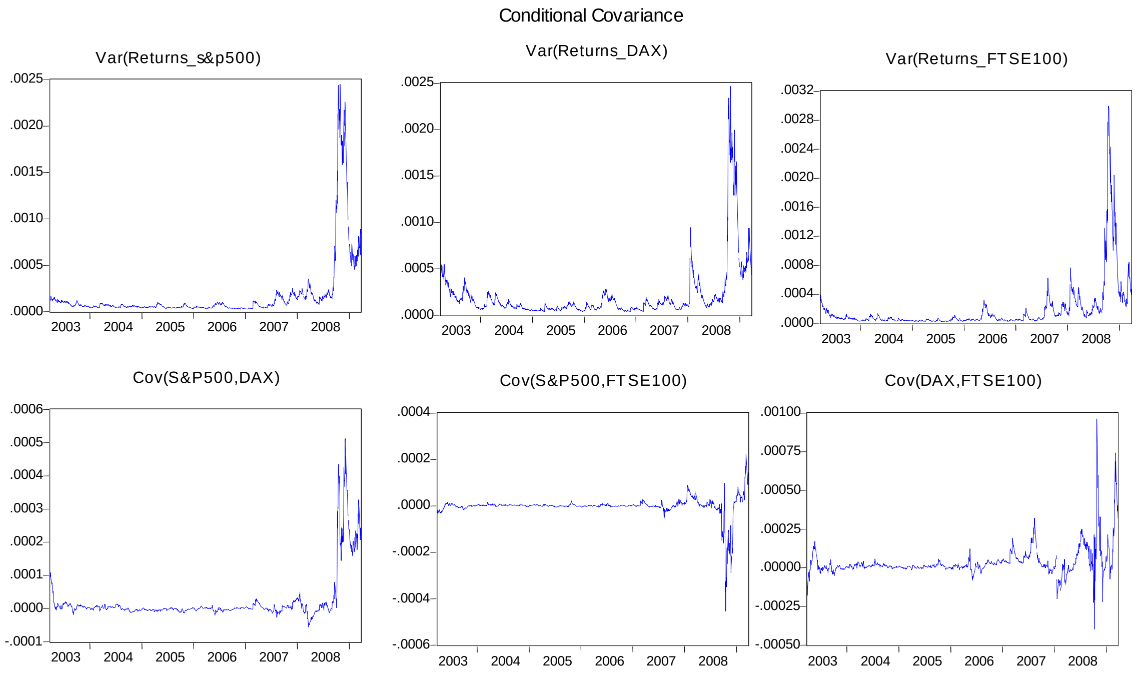


Figure2: Conditional variances and covariances of the returns series.

As we expect, the time period after the second semester of 2007 is characterized by high volatility and correlation between the markets. The (S&P500) and (FTSE100) indexes are negative correlated but the (S&P500, DAX) are positive correlated at the time space which begins the financial crisis.

4. CONCLUSIONS

Returns have some special features that cannot be analysed by the basic time series models. That features are:

1. The distribution of the financial time series, such as stock index returns, have heavier tails in contrast with the normal distribution
2. The returns are uncorrelated for different time period
3. Large changes in returns are followed by large changes and moreover, small changes in returns are followed by small changes. So, there is a cluster for changes on returns.

Such characteristics as the above can be captured only by financial models for heteroskedasticity such as ARCH and GARCH and the family of them. The basic element of those models is that they consider the conditional time-varying variance as given and not as a problem that it is necessary to fix it. This effect is extremely important because real data are behaved like this. The effect which is accrued by the above is reported as volatility clustering.

We applied volatility models such as ARCH, GARCH and EGARCH on four US stock indices: Dow Jones, NYSE, NASDAQ and S&P 500. The time horizon for our data sample is six years from (28/07/2002) to (28/07/2008).The first two models capture the volatility clustering effect and the third model captures the leverage effect. We concluded that the EGARCH model is the best fitted process for all our sample of data, based on AIC minimum criterion. Additionally, it is observed that we have high volatility periods at the beginning and at the end of our estimation period for all stock indices which are the time spaces between (28/07/2002-01/08/2003) and (11/08/2007-28/07/2008). Finally, we formulate and estimate a multivariate volatility model, DVEC(1, 1), in order to show the volatility clustering and time varying covariances between three major stock markets (S&P500, FTSE100, DAX), which play an important role in the global financial world during the time interval of the current (crucial) financial crisis.

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"Consumption Patterns: Empirical Analysis in Greece and the EU"

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Abstract

This paper analyses the structure of the consumption patterns in Greece and the European Union and examines the convergence hypothesis of these patterns during the last fifteen -year period. The convergence hypothesis is tested by using a statistical and econometrical framework. The analysis covers Greece and 14 other countries of the European Union, as well as 2 sub-groups of these countries (Euro zone and Mediterranean countries) for the time period 1993-2007. The estimated results become more robust when adding control variables to the analysis and tend to accept the convergence hypothesis.

JEL: C10, D12, E21
Keywords: Consumption, Consumption Patterns, Convergence

1 Introduction

Research on consumption patterns consists an important field of applied economics, as it is linked to individual and social behavior as well as to economic, social, political and cultural international developments. Nowadays, in the globalization era, the question of whether economies converge is in the center of scientific investigation, on a theoretical as well as an empirical level. Consumption pattern convergence is relevant to the income convergence across economies. The specific question that is risen is to which point does the consumption pattern and consumption behavior of households in general, tend to homogenize on international level.

This topic becomes of more importance in the case of EU economies, where the acceleration of the European integration process imposes the adoption of convergence policies on multiple levels by all member countries. A series of questions are thus being posed: To which level do consumption patterns converge in the EU? Does this convergence occur equally across all EU countries or is it limited across specific groups of these countries? Which are the determinants of this process? To which point is consumption behavior affected by the European integration process? The answers to these questions assist in understanding consumption behavior and are of particular use to exercising macroeconomic policies as well as shaping business strategies (advertising and marketing).

The present paper aims at empirically investigating the consumption pattern convergence hypothesis across EU countries, putting particular emphasis on the case of Greece. We examine the behavior of consumption components as well as twelve consumption expenditure shares, which shape the consumption pattern. The analysis covers the recent fifteen- year period (1993-2007) and refers to 15 EU member countries. The Greek consumption pattern is presented in a special part of this study. Moreover, in order to reveal possible differentiations which may occur, depending on the composition of the sample of countries, the analysis of the consumption pattern will also take place on the basis of the 12 euro zone member countries and 4 Mediterranean countries. Our methodology consists of estimating convergence using statistical indexes (σ-convergence) and econometrical framework. Statistical data have been drawn from Eurostat.

This paper is composed as follows: In Section 2 we examine consumption's main components and factors. Section 3 reviews the empirical literature on consumption pattern convergence, while in Section 4 we look into the development of the consumption pattern in the EU and Greece in particular, during the last 15 years. In the next Section (5) follows the methodological framework and the empirical analysis of consumption pattern convergence. Section 6 summarizes the final results.

2 Consumption's determinants

According to Keynsian theory, as well as more recent theoretical and empirical approaches, income consists one of the main determinants of consumer behavior (Friedman (1957), Ando & Modigliani (1963), Duisenberry (1971)). An increase in income, however, does not necessarily lead to an equal rise in all categories of consumption which compose the consumption pattern, meaning all goods and services consumed by each household (ECE, 1997a).

Apart from income, there are other basic macro-variables which affect consumption behavior, such as taxes, the interest rate and public expenditure. Taxes affect private consumption directly through their effect on available income. An increase in taxes, especially a permanent one, reduces consumers' income and, consequently, the amount of goods and services consumed. Empirical research on OECD countries during the 1990's, confirm the negative relationship between taxes and consumption (Carey & Tchilinguirian, 2000).

The effect of interest rate on consumption is indirect, considering that the immediate effect of a change of the interest rate appears on households' savings. If the interest rate increases, households tend to consume more and save less (Balassa, 1990). However, this negative relationship is not always empirically verified (Bosworth, 1993). Public expenditure has also been considered to affect consumption, since it can substitute private expenditure. Empirical analysis does not confirm this hypothesis either (Katsaitis & Angastiniotis, 1990).

Apart from macro-variables, a series of factors affect definitely the consumption's structure and the consumption pattern. A rather characteristic factor which is thought to affect the consumption pattern is the evolution of households' age distribution and the increase in the ageing of population in particular. Empirical research concluded that the ageing of population acts positively on expenditure for health as well as expenditure on energy and household equipment (Martins et al, 2005). On the other hand, the ageing of population has negative effects on expenditure on education and entertainment.

Household size is considered to affect the change of the consumption pattern. A reduction in the size of the household will limit the appearance of economies of scale which is resulted from the consumption of certain goods by a relatively large number of people living together, as in the case of electrical energy consumption (European Commission, 2001). The level of urbanization consists an additional variable in shaping the consumption pattern, taking into account that households in rural areas produce part of their food, thus presenting a high level of self-consumption (Kouremenos & Avlonitis, 1995). A reduction in the number of rural households combined with a rise of urbanization therefore, affects the distribution of income between different categories of consumption. The increased participation of women in the labor market as well as lifestyle patterns, are also important factors shaping consumption.

Other parameters affecting the consumption pattern are national education and health systems and, of course, national pension systems. The more developed is the education system and the more a health system offers complete and high-quality services, the more the need for individuals to turn to the private sector for the same services decreases. As far as the pension system is concerned, its affect on household savings and consumption of social security services remains important (Bailliu & Reisen, 1998).

Apart from quantitative parameters, there exist qualitative factors which affect the shaping of the consumption pattern. Modern approaches studying consumer behavior, consider that culture and society's system of values acts decisively on the distribution of household budget to various goods (Hofstede, 2001). Many of the differences observed on the level of different consumption categories can be interpreted through differences in long-term cultural behavior (Bell, 1999). In other words, the existing system of values as well as habits and mentalities significantly affect the prevailing consumption pattern (Thogersen & Olander, 2002). Finally, environmental conditions increase the consumption of certain goods while limiting the consumption of others (ECE, 1997b).

3 Consumption pattern convergence

Convergence, meaning the process in which countries obtain similar characteristics while decreasing their differences, is defined by contemporary conditions on economic, political and cultural level.

The classic framework developed by Solow (1956) has been the starting point of theoretical and empirical approaches on convergence across economies. With the development of research, the original framework has expanded and, in some points revised (ex. endogenous growth theories), in order to better define the mechanisms that cause convergence or divergence across economies (de la Fuente (2000), Temple (1999)).

Convergence across economies is empirically approached mainly through two measures of convergence: σ-convergence and β-convergence. Σ – convergence refers to a statistical formula (average and standard deviation (σ^2)), of an economic variable reflecting economic activity (usually, GDP per capita) of the sample of economies under examination. Σ – convergence stands closer to the sense of convergence, where economies converge (diverge) when the coefficient of variation of income per capita decreases (increases) over a period of time. B-convergence derives from component β of an econometrical framework referring to the relationship between the annual growth rate and the initial level of GDP per capita (Barro & Sala-i-Martin (1992)). It is considered that β-convergence across the examined economies takes place if it is empirically concluded, by average, that the initial level of income per capita and the annual growth rate are negatively linked. The rate of convergence (divergence) across economies is defined by the measure of β component of the framework, which is valued negatively (or positively).

In essence, the methodology usually followed in order to verify consumption convergence derives from the one used to cross-section convergence across economies. In other words, the use of statistical dispersion measures and econometrical frameworks applies in the case of consumption expenditure as well[1]. The study of Fiaschi & Lavezzi (2005) consists an attempt to investigate consumption expenditure convergence. With the use of econometric methods, the study concludes that consumption expenditure per capita in EU regions does not converge, since the dispersion of values has increased in the time period 1986-1998 compared to 1977-1985.

Konya & Ohashiz (2004) studied the development of the consumption pattern in eight[2] categories of goods and the tension towards consumption behavior homogenization in 22 OECD countries during 1985-1999. With the use statistical approaches and econometrical frameworks they concluded to the existence of consumption pattern convergence to a certain level. These conclusions have been confirmed in their later research (Konya & Ohashi, 2007). Finally, consumption pattern convergence has been empirically verified in countries outside OECD, such as in the case China's regions during 1982-1998 (Wan, 2005).

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[1] The same methodology to test the convergence hypothesis is followed for various economic variables, such as unemployment, productivity etc.

[2] The OECD classification is different to that of Eurostat. Eurostat separates households' consumption expenditure to twelve categories.

Mooij & Hofstede (2002), based on each nation's cultural expression, using 5 different categories by Hofstede (2001), developed the role of cultural variables in shaping consumption behavior. They established significant differences in the type as well as the use of goods and services consumed by the population of developed countries. In a later research, Mooij (2003) concluded to a differentiation across EU countries concerning categories of consumption, such as in the car and radio market, newspapers and book reading as well as in the daily duration of television viewing. Each country's culture is considered to better interpret the shaping of the consumption pattern in the case of developed countries. In fact, Mooij (2003) suggests that as economies grow, the role of income (as an interpretation variable of the type of goods consumed) fades and culture prevails in its place. This fact is of particular importance when referring to the role of advertising and marketing and the need to differentiate their approach according to each society (Dahl, 2005).

While studies on consumption pattern convergence are limited, a greater number of empirical studies exist, on the verification of convergence for specific categories of goods and the consumption of food in particular. Regmi & Unnevehr (2005) investigated if convergence occurs in the case of food consumption expenditure per capita across EU countries, USA and Canada during 1990-2004, concluding to the existence of (σ and β) convergence. Similar results were obtained by Herrmann & Roder (1995) for the time period 1980-1995. Airenman & Brooks (2005) investigated convergence in beer and wine consumption across 38 countries. It has been established that during 1963-2000 wine and beer consumption converge, while the rate of convergence is particularly high in English-Saxon countries.

Finally, certain researchers attempt to define convergence across economies through newly established conditions, on economic and social level. Levitt (1983) established a rather characteristic point of view on the role of globalization. He suggested that the fast spread of new technologies, combined with advertising and marketing, lead to homogenization of consumption needs and preferences, since consumers, regardless of any of their special characteristics, prefer high quality products offered in low prices. According to Levitt, globalization will turn the world into a human-cultural model and a homo-cultural market, where all consumers can be approached through the same advertising images and values, regardless of their cultural background. If this is the case, then marketing can benefit from newly-formed advantages. Brands and images of goods will be standardized without any particular effort and will spread without demanding any significant adjustments to local markets. As a result, cost of advertising will decrease and both producers and consumers will benefit (Dahl, 2005). This process is achieved through the activation of multinational corporations, the decrease of transport cost and, therefore, an increase in cross-border movement, the emergence of global information and entertainment networks and also through an overall improvement in means of communication (Czinkota & Ilkka, 1993). Moreover, further adoption of common production methods and forms of "western type" governance will contribute in creating common values and beliefs (Richter & Buttery, 2002).

In this framework, the EU's decisions on implementing the Economic and Monetary Union contribute in forming a convergence process on all levels (Sinn & Ochel, 2003). Therefore, it appears as particularly interesting to verify to which point the consumption pattern across EU countries converges and moves towards a certain level or to which point EU citizens' different cultural background affects consumption and creates divergence.

4 Consumption pattern in EU and Greece: composition and evolution

According to Eurostat rules, a first categorization of consumption takes place using two-digit coding, where all goods and services consumed are placed in a different category, according to their use. Eurostat's 12 consumption categories are the following[3]: Alcoholic beverages and tobacco, clothing and footwear, communications, education, food and non-alcoholic beverages, furnishings and household equipment, health, housing/water/electricity/gas, miscellaneous goods and services, recreation and culture, restaurants and hotels and, finally, transport.

The category which draws the largest part of EU-15's[4] average household income is "housing/water/electricity/gas", followed by "transport" and "food and non-alcoholic beverages". On the other hand, "education" is the category where the least amount of average household income (EU-15) is spent (see Table 1). According to their growth rate, categories displaying the greatest percent increase are "communications" and "miscellaneous goods and services", while "food and non-alcoholic beverages" and "clothing and footwear" have appear to have the greatest decrease during 1993-2007 in EU-15.

Table 1
Expenditure Shares and Annualised Average Growth Rates

	Expenditure Shares				Annualised Average Growth Rates			
	E.U. (15)	Eurozone (12)	Mediter. Countries	Greece	E.U. (15)	Eurozone (12)	Mediter. Countries	Greece
Alcoholic beverages and tobacco	4,4	4,4	3,4	4,5	-1,24%	-0,99%	-0,31%	0,00%
Clothing and footwear	6,3	6,6	8,3	10,6	-1,30%	-1,49%	-1,19%	-1,13%
Communications	2,4	2,4	2,3	2,1	4,36%	4,89%	4,73%	10,71%
Education	0,9	0,9	1,5	2,1	0,64%	0,57%	0,00%	1,79%
Food and non-alcoholic beverages	13,2	13,6	16,4	16,8	-1,47%	-1,50%	-1,39%	-0,75%
Furnishings and household equipment	6,4	6,7	6,9	6,3	-0,55%	-0,71%	-0,77%	-0,64%
Health	3,5	3,8	4,4	5,6	0,62%	0,49%	-0,04%	1,24%
Housing, water, electricity, gas	20,9	19,9	16,0	16,6	0,56%	0,87%	1,02%	-0,49%
Miscellaneous goods and services	10,4	10,3	8,3	5,6	1,15%	1,34%	2,80%	2,43%
Recreation and culture	9,3	8,8	7,1	6,5	0,62%	0,45%	1,50%	5,00%
Restaurants and hotels	9,2	9,7	13,2	14,9	0,04%	-0,06%	0,29%	-0,34%
Transport	13,3	13,1	12,4	9,7	0,61%	0,54%	0,54%	1,91%

The previously mentioned results show no significant differentiation when the analysis focuses on euro zone's 12 member-countries: removing United Kingdom, Denmark and Sweden from the sample seems to have no significant effect. On the other hand, when limiting the sample to the four Mediterranean countries (Greece, Italy, Spain and Portugal), results are significantly different. In this case, the

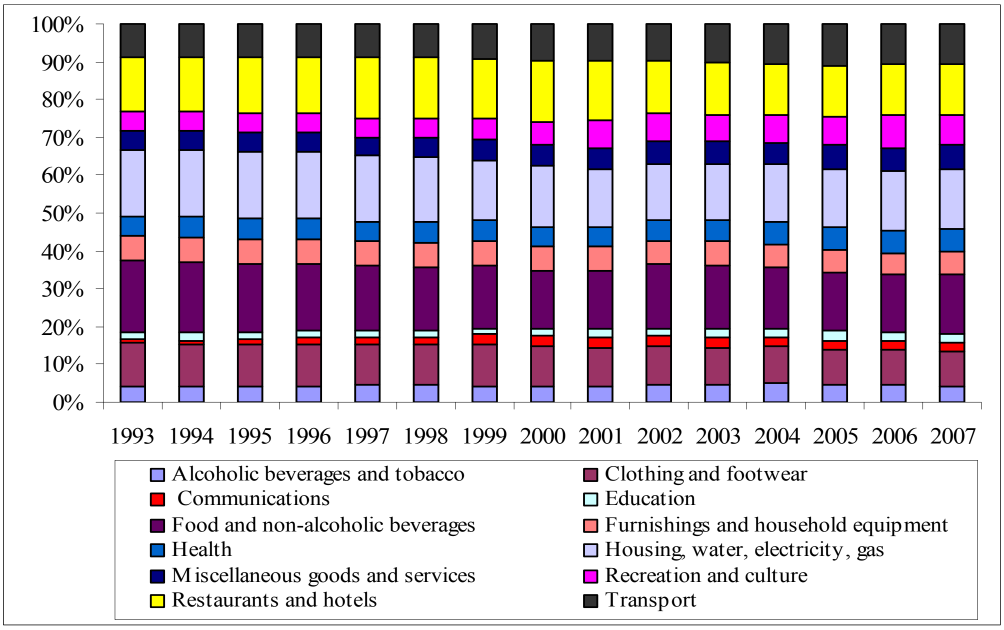
3 The source of data is Eurostat (Living Conditions and Welfare, Household Budget Survey).
4 EU -15 member countries are: Denmark, Belgium, Germany, France, Greece, Italy, Spain, Ireland, Luxembourg, United Kingdom, Sweden, Finland, Netherlands, Austria and Portugal.

consumption category absorbing the largest part of average household income is "food and non-alcoholic beverages", followed by "housing/water/electricity/gas", while an important part of income is spent on "restaurants and hotels". When referring to the growth rate of consumption categories for Mediterranean countries, "alcoholic beverages and tobacco" shows a significantly lower percent decrease, while "miscellaneous goods and services" has increased twice as much during 1993-2007 (2,8%) compared to EU-15 (1,15%).

In the case of Greece, the consumption pattern shows similarities as well as differentiations compared to either group of countries (EU-15, euro zone or Mediterranean countries) average. "Food and non-alcoholic beverages" absorbs the largest part of the average Greek household income, as is the case for Mediterranean countries. A large part of Greek average income seems, however, to be consumed on "clothing and footwear" and Greek households spend more than twice as much of their income on "education", compared to EU-15. "Education", as a consumption category in Greece, has also appears to have twice the growth rate of EU-15 average. Finally, Greece shows no change in the percentage of household income spent on "alcoholic beverages and tobacco" from 1993 to 2007, when in all groups of countries this consumption category of goods and services displayed a negative growth rate.

When studying the evolution of consumption pattern in Greece over the years, it, also, becomes clear that the percentage of household income spent on "communications" has significantly increased during the time period in question (from 1% in 1993 to 2,5% in 2007). We also notice an increase of consumption on "recreation and culture". Finally, the percentage of income spent on goods and services under the category "restaurants and hotels" in 2007 is smaller than in 1993, even thought in the meantime it showed the tension to increase (see Figure 1).

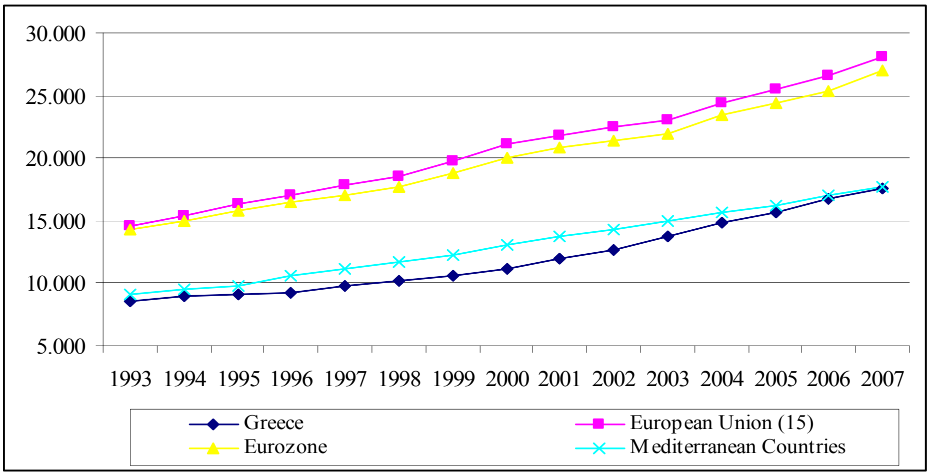
Figure 1
Greek Consumption Pattern (1993-2007)



It is particularly interesting to attempt a linkage between the above mentioned consumption shares, household income and the relevant price indexes. During the period of study (1993-2007) all EU-15 member countries displayed a significant increase in per capita income: it rose from € 15.000 in 1993 to more than € 25.000 in

2007 (see Figure 2). Mediterranean countries as well as Greece display similar income increase, though still lacking behind the EU average.

Figure 2
Net national income at market prices (Euro per inhabitant)



As far as the price level and its growth rate are concerned, we begin by noticing that "Education" still presents the highest price index in the EU-15 as well as in Euro zone. On the other hand, in Mediterranean countries the consumption category with the highest price index is "food and non-alcoholic beverages" while in Greece, it's "housing/water/electricity/gas".

Table 2
Prices and Annualised Average Growth Rates (average figures, 1993-2007)

	Price Index				Annualised Average Growth Rates			
	E.U. (15)	Eurozone (12)	Mediter. Countries	Greece	E.U. (15)	Eurozone (12)	Mediter. Countries	Greece
Alcoholic beverages and tobacco	100,57	102,63	101,65	98,45	3,96%	4,19%	5,71%	5,30%
Clothing and footwear	99,20	100,88	101,25	100,71	0,56%	0,67%	2,33%	3,80%
Communications	101,27	103,21	99,45	101,84	-1,71%	-1,77%	-1,19%	-1,46%
Education	101,59	103,38	102,59	101,15	4,51%	4,61%	4,97%	4,72%
Food and non-alcoholic beverages	101,47	102,86	103,26	101,26	1,81%	1,84%	2,80%	3,34%
Furnishings and household equipment	99,23	100,63	99,66	98,47	1,56%	1,56%	2,40%	2,62%
Health	99,50	101,04	99,56	102,19	3,18%	3,03%	2,53%	3,23%
Housing, water, electricity, gas	100,31	101,29	102,43	104,18	4,16%	4,07%	4,43%	4,49%
Miscellaneous goods and services	98,34	99,94	100,09	112,69	3,04%	3,12%	3,85%	3,87%
Recreation and culture	99,64	101,10	100,90	103,28	0,64%	0,78%	1,84%	2,22%
Restaurants and hotels	100,80	102,23	101,42	95,36	3,26%	3,14%	3,44%	2,31%
Transport	98,96	100,40	101,26	100,09	2,83%	2,82%	3,38%	3,07%

When looking into the growth rates, the only category with a negative rate, in all groups of countries as well as in Greece, is "communications". "Education" price index presents the highest growth rate in EU and euro zone, while in Mediterranean countries and Greece it is "alcoholic beverages and tobacco" that "take the stand".

Let us now move on to estimating the correlation coefficients among 12 expenditure shares of goods and income per capita, as well as among these shares and their matching price indexes (see Table 3). "Clothing and footwear" presents the most negative correlation to income in all groups of countries and Greece, followed by "furnishings and household equipment" and "food and non-alcoholic beverages". On the other hand, shares of goods displaying positive correlation are "miscellaneous goods and services" as well as "recreation and culture". The above mentioned correlations tend to confirm Engel's law, referring to the negative relationship between a rise in income and in the consumption share of food and basic necessities in general. It should be noted that, unlike other countries, Greece presents a negative correlation between income and the shares of good categorized as "housing/water/electricity/gas". This is probably due to the particularities of the greek market.

As for the price indexes, we notice a significantly negative correlation to expenditure shares when it comes to "clothing and footwear", "communications" and "furnishings and household equipment", followed by "food and non-alcoholic beverages". On the contrary, "miscellaneous goods and services" as well as "recreation and culture" are shares of goods which display positive correlation with income and their corresponding prices. Finally, "alcoholic beverages and tobacco" is negatively correlated with income and its price index in the case of EU-15 and euro zone while positively correlated in Mediterranean countries. Moreover, in the case of Greece the correlation is particularly high.

Table 3
Correlation Coefficient Expenditure Shares of Goods (1993-2007)

	with Income				with Corresponding Prices			
	E.U. (15)	Eurozone (12)	Mediter. Countries	Greece	E.U. (15)	Eurozone (12)	Mediter. Countries	Greece
Alcoholic beverages and tobacco	-0,81	-0,63	0,30	0,55	-0,81	-0,63	0,26	0,59
Clothing and footwear	-0,98	-0,98	-0,99	-0,98	-0,91	-0,97	-0,98	-0,96
Communications	0,92	0,91	0,90	0,68	-0,92	-0,94	-0,74	-0,58
Education	0,84	0,74	0,21	0,80	0,87	0,78	0,25	0,70
Food and non-alcoholic beverages	-0,93	-0,92	-0,86	-0,62	-0,90	-0,86	-0,81	-0,64
Furnishings and household equipment	-0,95	-0,96	-0,93	-0,74	-0,92	-0,96	-0,90	-0,70
Health	0,82	0,77	0,25	0,93	0,86	0,82	0,26	0,90
Housing, water, electricity, gas	0,85	0,92	0,84	-0,66	0,86	0,93	0,87	-0,64
Miscellaneous goods and services	0,95	0,96	0,96	0,93	0,97	0,96	0,95	0,88
Recreation and culture	0,90	0,81	0,97	0,94	0,91	0,77	0,96	0,92
Restaurants and hotels	-0,13	-0,67	0,49	-0,55	-0,18	-0,71	0,45	-0,16
Transport	-0,81	-0,63	0,30	0,55	0,73	0,75	0,60	0,96

We should note, however, that in most cases of shares of goods, the coefficients of correlation are similar for all groups of countries as well as Greece. These similarities offer a fist picture of certain common features in consumer behavior, concerning the goods people choose to buy when faced with an increase in income or a change in price indexes.

5 Empirical study

5.1 σ-convergence: research methodology and results

In order to empirically investigate consumption pattern convergence across EU countries and Greece, we originally check the σ-convergence hypothesis, offering a first impression on whether convergence occurs, while next, we examine the convergence hypothesis through an econometrical framework. Σ-convergence is empirically verified through the estimation of standard deviation. Let us note that σ-convergence serves mainly as a conclusive analysis, which in any case offers a number of useful results (Prontzas & Lolos, (2008)). The usual measures for estimating the degree of data homogeneity, are standard deviation and the coefficient of variation (Papadaskalopoulos (2000)). We estimate the mean convergence for a certain time period using the following formula:

$$MCV = \left[\left(\frac{CV_{t1} - CV_{t2}}{CV_{t1}}\right)\right] \cdot \frac{100}{(t_2 - t_1)} \quad (1)$$

where *MCV* is the per cent mean convergence for a certain time period, CV_{t1} is the coefficient of variation at the first year of the time period, CV_{t2} is the coefficient of variation at the last year, t1 and t2 is the first and the last year of the period respectively. The diachronic reduction (increase) of the coefficient of variation implies convergence (divergence) in the testing variable. In other words negative (positive) price of MCV indicator implies convergence (divergence).

The analysis covers EU-15 and euro zone, Mediterranean countries and, of course, Greece. Statistical data have been drawn from Eurostat's database. Our study covers the time period 1993-2007, for which we have the necessary data available. Before proceeding to estimating σ-convergence for consumption expenditure shares, however, we are going to examine whether this phenomenon occurs for the main variables affecting the size as well as the composition of household consumption. We are, more specifically, going to verify if σ-convergence occurs across taxation, public expenditure, household size and the aging index[5].

As previously mentioned (see section 2) these variables tend to define consumer behavior. In this way, we will be able to better interpret the estimated results on expenditure shares. Let it also be noted that since income convergence in EU countries has been thoroughly studied, the present paper will not deal extensively with this topic. Most empirical studies conclude that income per capita tends to converge through time, among European countries[6] .

Starting by verifying taxation convergence, we move on to distinguishing taxation on wealth and income from taxation on production and imports. We then conclude that σ-convergence occurs in both forms of taxation across almost all groups of countries under study (see Table 4), although taxation on production displays a

[5] The age index is estimated by calculating the mean of population over the age of 65 to the population under the age of 15.

[6] This topic lies, nowadays, in the center of scientific interest. See (among others) research carried out by Mathur (2005), Geppert, Happich & Stephan (2005), Fiaschi & Lavezzi (2005), Boldrin & Canova (2001).

faster rate of convergence in EU-15 and the euro zone while the opposite happens in the case of Mediterranean countries. Σ-convergence is also confirmed for public expenditure and the aging index, while countries tend to diverge in the case of average household size.

Table 4
Σ-convergence for consumption determinants [average figures, period 1993-2007]

		Taxes on production and imports*	Taxes on income, wealth, etc.*	Total general government expenditure*	Household Size	Aging Index
E.U. (15)	Average	13,51%	14,50%	47,68%	2,50	90,18%
	Stand. Dev.	1,85	5,55	6,79	0,32	0,19
	Coef. Var.	0,14	0,38	0,14	0,13	0,21
	Mean Converg. (Diverg.) Index	-1,92%	-0,59%	-1,77%	0,57%	-1,89%
Eurozone (12)	Average	13,01	12,66	46,63	2,57	92,93%
	Stand. Dev.	1,40	3,26	6,02	0,32	0,21
	Coef. Var.	0,11	0,26	0,13	0,12	0,23
	Mean Converg. (Diverg.) Index	-2,95%	-1,51%	-1,28%	0,55%	-0,18%
Mediter. Countries	Average	12,77	10,40	44,63	2,84	112,50%
	Stand. Dev.	1,43	2,84	3,84	0,23	0,12
	Coef. Var.	0,11	0,27	0,09	0,08	0,11
	Mean Converg. (Diverg.) Index	-0,18%	-3,36%	-0,09%	0,80%	-0,41%

*As percentage of GDP

Next, the estimation of σ-convergence for consumption determinants among Greece and the relevant EU-average, euro zone and Mediterranean countries. In this case we notice some change in results compared to previous estimations, since income taxation and public expenditure across Greece and the three groups of countries in question now converge, compared to production taxation which diverges.

Table 5
Σ-convergence for consumption determinants in Greece [average figures, Period 1993-2007]

		Taxes on production and imports*	Taxes on income, wealth, etc.*	Total general government expenditure*	Household Size	Aging Index
Greece with the average of E.U. (15)	Average	12,99	11,13	46,28	2,64	101,3%
	Stand. Dev.	0,75	4,66	2,45	0,22	0,15
	Coef. Var.	0,06	0,42	0,05	0,08	0,14
	Mean Converg. (Diverg.) Index	3,98%	-1,20%	-5,59%	0,20%	6,01%
Greece with the average Eurozone (12)	Average	12,75	10,20	45,73	2,68	102,6%
	Stand. Dev.	0,46	3,35	1,78	0,17	0,13
	Coef. Var.	0,04	0,33	0,04	0,06	0,12
	Mean Converg. (Diverg.) Index	7,82%	-1,41%	-6,34%	1,68%	7,86%
Greece with the average of Mediter. Countries	Average	12,64	12,37	42,76	2,70	94,32%
	Stand. Dev.	0,50	1,84	0,84	0,03	0,03
	Coef. Var.	0,04	0,15	0,02	0,01	0,04
	Mean Converg. (Diverg.) Index	19,93%	-2,38%	-6,77%	-5,39%	-1,94%

*As percentage of GDP

As far as the rest two components are concerned (household size and aging index) they tend to converge only in the case when our benchmark is the Mediterranean countries average.

After analyzing consumption's determinants, we proceed firstly to the analysis of final consumption as an aggregation figure. Household consumption expenditure in EU countries is averagely rated to 54% of GDP during 1993-2007. Household consumption expenditure, however, diverges across all of EU-15 and the euro zone (Table 6). This result agrees with Fiaschi & Lavezzi (2005), who have concluded that consumption expenditure per capita during 1986-1998 diverges across EU regions. Only in the case of Mediterranean countries, final consumption tends to converge. Divergence also occurs in the case of consumption expenditure among the EU, euro zone, Meditteranean and the Greek average. In other words, consumption expenditure in Greece does not converge with the three groups of countries under study.

Table 6
Σ-convergence in consumption [average figures, period 1993-2007]

		Final Consumption of Household (as percentage of GDP)	
		Among each group	Between each group and Greece
E.U. (15)	Average	54,10%	62,78%
	Stand. Dev.	8,00	12,27
	Coef. Var.	0,15	0,20
	Mean Converg. (Diverg.) Index	3,51%	0,73%
Eurozone (12)	Average	54,42%	62,94%
	Stand. Dev.	8,29	12,05
	Coef. Var.	0,15	0,19
	Mean Converg. (Diverg.) Index	3,82%	0,84%
Mediter. Countries	Average	62,64%	51,89%
	Stand. Dev.	6,23	6,24
	Coef. Var.	0,10	0,12
	Mean Converg. (Diverg.) Index	-0,52%	2,01%

So far we have verified σ-convergence for some of consumption's main deterinants, while consumption as a whole diverges across the entire EU. When we come to question the relationship between Greece and all other three groups of countries, consumption expenditure diverges, while its determinants tend to converge as well as diverge. The question now lies on how the consumption pattern behaves.

This study, therefore, moves on to estimate σ-convergence for all 12 expenditure shares composing the consumption pattern, originally across EU-15, euro zone and Mediterranean countries and next across each of these 3 groups of countries and Greece. Our first result is that the majority of expenditure shares converge across all three groups of countries. In the case of Mediterranean countries, in particular, 9 consumption categories converge, representing 84 % of total consumption (see Table 7).

EU also converges on 9 consumption categories, which represent more than 80% of consumption, while across euro zone countries 7 expenditure shares converge, or, otherwise, 64% of consumption. As for the rate of convergence, this phenomenon is rather intense in the case of household equipment across EU and euro zone. "Communications" stand out as the consumption category with the highest rate of convergence across Mediterranean countries. "Housing/water/electricity/gas" strongly tends to converge across the entire EU-15 as well as all separate groups of countries.

This conclusion is of particular importance, since this group of goods represents the largest households' consumption share in the EU (more than 20%).

Table 7
Σ-convergence in Expenditure Shares [Period 1993-2007]

	European Union (15)				Eurozone (12)				Mediterranean Countries			
Categories	Aver.	Stand. Dev.	Coef. Var.	Mean Converg. (Diverg.) Index	Aver.	Stand. Dev.	Coef. Var.	Mean Converg. (Diverg.) Index	Aver.	Stand. Dev.	Coef. Var.	Mean Converg. (Diverg.) Index
Alcoholic beverages and tobacco	4,35	1,86	0,43	0,36%	4,39	2,09	0,47	0,01%	3,44	0,90	0,26	**-1,10%**
Clothing and footwear	6,34	1,65	0,26	**-0,19%**	6,61	1,71	0,26	0,89%	8,32	1,84	0,22	0,53%
Communi-cations	2,39	0,50	0,20	1,06%	2,40	0,50	0,20	0,60%	2,34	0,21	0,10	**-5,11%**
Education	0,89	0,52	0,59	**-1,06%**	0,92	0,52	0,57	**-1,09%**	1,46	0,50	0,34	1,49%
Food and non-alcoholic beverages	13,23	2,49	0,19	0,02%	13,61	2,59	0,19	0,10%	16,45	1,19	0,07	**-1,35%**
Furnishings and household equipment	6,45	1,10	0,17	**-3,38%**	6,71	1,00	0,15	**-3,11%**	6,85	1,08	0,16	0,30%
Health	3,47	1,19	0,34	**-1,40%**	3,77	1,12	0,30	**-1,43%**	4,42	1,32	0,30	**-1,82%**
Housing, water, electricity, gas	20,90	4,35	0,21	**-2,72%**	19,93	3,72	0,19	**-1,97%**	15,97	2,54	0,16	**-2,84%**
Miscellaneous goods and services	10,44	2,36	0,23	**-2,22%**	10,32	2,57	0,25	**-2,29%**	8,28	2,30	0,28	**-1,94%**
Recreation and culture	9,28	1,94	0,21	**-0,24%**	8,79	1,84	0,21	**-1,17%**	7,15	1,24	0,18	**-3,17%**
Restaurants and hotels	9,19	4,24	0,46	**-0,06%**	9,65	4,38	0,45	0,19%	13,23	4,25	0,32	**-1,72%**
Transport	13,27	1,85	0,14	**-0,39%**	13,13	1,97	0,15	**-0,14%**	12,42	2,22	0,18	**-3,17%**
Number of converging categories			9				7				9	
Sum percentage of converging categories			80,23%				63,57%				83,69%	

On the other hand, the expenditure share on education displays a positive divergence rate across Mediterranean countries. In the case of consumption expenditure on alcoholic beverages and tobacco the convergence (divergence) index changes from one group of countries to another: when referring to all 15 member countries of the EU the index shows convergence, then remains stable in the case of euro zone and, when focusing on Mediterranean countries, the index indicates convergence. Also, food and communications expenditure shares tend to diverge for both EU-15 and euro zone country members, while the same consumption expenditure categories converge across Mediterranean countries. Finally, expenditure on health, miscellaneous goods and services, restaurants and hotels, recreation and culture as well as transport converge across all three groups of countries.

We have therefore established σ-convergence for most expenditure shares of goods across the EU-15, euro zone and Mediterranean countries. We now come to examine whether Greece's consumption pattern converges with each of the three groups of countries under study (see Table 8). Calculations show that 9 categories of goods in Greece converge with the EU as well as euro zone average. These categories represent 69% of total consumption expenditure. When compared to the Mediterranean countries average, it significantly rises (almost to 90%), but converging consumption shares reach the same number (9).

Table 8
Σ-convergence in Expenditure Shares between Greek and the benchmarks [Period 1993-2007]

	Greece with the average of E.U. (15)				Greece with the average Eurozone (12)				Greece with the average of Mediter. Countries			
Categories	Aver.	Stand. Dev.	Coef. Var.	Mean Converg. (Diverg.) Index	Aver.	Stand. Dev.	Coef. Var.	Mean Converg. (Diverg.) Index	Aver.	Stand. Dev.	Coef. Var.	Mean Converg. (Diverg.) Index
Alcoholic beverages and tobacco	4,43	0,24	0,05	2,43%	4,45	0,20	0,05	1,18%	6,55	0,75	0,12	**-1,79%**
Clothing and footwear	8,45	2,99	0,35	0,43%	8,59	2,80	0,33	1,03%	6,77	1,59	0,24	3,92%
Communi-cations	2,27	0,21	0,11	**-5,94%**	2,27	0,20	0,10	**-5,65%**	2,01	0,16	0,09	**-5,84%**
Education	1,49	0,84	0,56	**-0,21%**	1,50	0,83	0,54	**-0,11%**	0,98	0,44	0,45	10,17%
Food and non-alcoholic beverages	15,17	2,74	0,18	**-0,63%**	15,35	2,47	0,16	**-0,55%**	13,54	0,51	0,04	**-0,32%**
Furnishings and household equipment	6,39	0,09	0,01	**-3,74%**	6,52	0,27	0,04	**-3,64%**	7,16	0,37	0,05	**-3,66%**
Health	4,58	1,57	0,34	**-0,96%**	4,73	1,36	0,29	**-0,92%**	3,18	0,90	0,29	4,67%
Housing, water, electricity, gas	18,66	3,17	0,17	1,80%	18,18	2,48	0,14	4,65%	18,56	0,73	0,04	**-3,86%**
Miscellaneous goods and services	8,02	3,43	0,43	**-1,44%**	7,96	3,34	0,42	**-1,25%**	8,83	1,90	0,22	**-0,93%**
Recreation and culture	7,90	1,96	0,26	**-5,62%**	7,65	1,61	0,22	**-6,38%**	7,45	0,61	0,08	**-4,41%**
Restaurants and hotels	12,05	4,04	0,33	**-0,84%**	12,28	3,71	0,30	**-0,72%**	10,78	1,19	0,11	**-4,21%**
Transport	11,50	2,50	0,22	**-2,87%**	11,43	2,40	0,21	**-3,07%**	14,41	1,90	0,14	**-4,53%**
Number of converging categories	9				9				9			
Sum percentage of converging categories	69,35				69,69				89,27			

Greece converges with the EU, euro zone and Mediterranean countries average in the cases of communications, miscellaneous goods and services, recreation and culture, hotels and restaurants, food, household equipment and transport. We should specifically note that convergence is particularly high for both communications and recreation and culture. In the case of expenditure on education and health, Greece converges with the EU and euro zone average and not with Mediterranean countries, while the opposite happens in the case of "housing/water/electricity/gas». "Clothing and footwear" is a category where divergence occurs across Greece and all three groups of countries.

There is therefore evidence of convergence across Greece and the EU as well as euro zone average, concerning the distribution of consumption expenditure, which becomes stronger across Greece and Mediterranean countries. Otherwise said, it seems that Greece's consumption pattern becomes similar to that of EU and euro zone countries. These similarities become more intense in the case of Mediterranean countries. In order to extend our analysis we will next move on to test the convergence via an econometrical approach.

5.2 Econometrical approach

The econometrical framework in which lies the consumption pattern convergence analysis, is based on cross examining long term decrease of differences across two countries (or groups of countries), one of which is chosen as benchmark, on an expenditure share for a specific category of goods (Konya & Ohashiz, 2007). The model used in such cases is of the following form:

$$es_{i,j,t} - \bar{es}_{i,t} = \beta(es_{i,j,t-1} - \bar{es}_{i,t-1}) + \varepsilon_{i,k,t} \quad (1)$$

where $es_{i,j,t}$ (expenditure share) is the consumption expenditure share of the i category of goods in country j in time t , $\bar{es}_{i,t}$ is the same expenditure share of the i category of goods of our benchmark's average, in time t , expressed in logarithms. This framework is transformed into an Error Correction Model as follows:

$$\Delta z_{i,j,t} = \beta z_{i,j,t-1} + \gamma \Delta z_{i,j,t-1} + \varepsilon_{i,k,t} \quad (2)$$

where $z_{i,j,t}$ is $z_{i,j,t} = es_{i,j,t} - \bar{es}_{i,t}$, meaning the difference between the expenditure share logarithm of the i category of goods in country j and our benchmark's average. Δ represents the first differences, otherwise expressed as $\Delta z_{i,j,t} = z_{i,j,t} - z_{i,j,t-1}$, which take into account for possible serial correlation in the error $\varepsilon_{i,k,t}$. Next, we move on to estimating framework (2) for the case of Greece, taking EU's average as our first benchmark (Table 9).

Table 9

Convergence in Expenditure Shares (greece)-Estimation of β (standard error in parenthesis)

	with E.U. (15)	with Eurozone (12)	with Mediterranean Countries
Alcoholic beverages and tobacco	0,164 (0,169)	0,245 (0,195)	-0,008 (0,040)
Clothing and footwear	0,005 (0,009)	0,010 (0,010)	0,006 (0,017)
Communications	**-0,421**[a] (0,154)	**-0,398**[a] (0,159)	**-0,476**[a] (0,144)
Education	-0,001 (0,031)	-0,003 (0,030)	0,018 (0,063)
Food and non-alcoholic beverages	-0,014 (0,043)	-0,017 (0,047)	-0,141 (0,205)
Furnishings and household equipment	-0,132 (0,161)	-0,038 (0,072)	-0,026 (0,054)
Health	-0,001 (0,013)	-0,004 (0,016)	0,049 (0,037)
Housing, water, electricity, gas	0,030 (0,033)	0,039 (0,043)	**-0,204**[b] (0,088)
Miscellaneous goods and services	-0,016 (0,019)	-0,014 (0,021)	-0,001 (0,041)
Recreation and culture	-0,068 (0,050)	-0,077 (0,055)	-0,112 (0,097)
Restaurants and hotels	-0,010 (0,023)	-0,009 (0,025)	-0,056 (0,068)
Transport	-0,020 (0,027)	-0,021 (0,027)	-0,024 (0,032)

[a]: significant at the 99% confidence level, [b]: significant at the 95% confidence level

The results show that convergence is statistically important in the case of "communications", whereas for all rest expenditure shares we notice the existence of negative but not statistical significant β. The picture remains the same when taking euro zone's average as benchmark, while in the case of Mediterranean countries, convergence is also statistically important for "housing/water/electricity/gas" (and of course in communications).

In order to improve our estimation on framework (2) and take into account the definitive effect of prices and income on expenditure shares, we include these control variables in our model and conclude to the following transformation:

$$\Delta z_{i,j,t} = \beta z_{i,j,t-1} + \gamma \Delta z_{i,j,t-1} + \delta p_{i,k,t} + \eta m_{i,t} + \varepsilon_{i,k,t} \quad (3)$$

where $p_{i,k,t}$ is the difference between the price index logarithm of category *i* in country *j* in time *t* and our benchmark's average, $m_{i,t}$ is the difference of the income per capita average of country *j* in time *t* and our benchmark's average. Each country's income has been weighted by the sum of the log prices of all products in country *j* in time *t*, or in other words by the aggregate Stone price index (Moschini, 1995). This weighting guarantees the variable's stationarity.

Contrary to our previous outcomes, estimating framework (3) leads to statistically important results (Table 10). More specifically, communications, education, food, household equipment and health present statistically significant convergence regardless whether we consider EU or euro zone as benchmark.

Table 10

Convergence in Greek Expenditure Shares (Including income and price, standard error in parenthesis)

	with E.U. (15)	with Eurozone (12)	with Mediterranean Countries
Alcoholic beverages and tobacco	0,268 (0,177)	0,350 (0,197)	**-0,287** [c] (0,216)
Clothing and footwear	0,087 (0,087)	0,072 (0,101)	0,070 (0,180)
Communications	**-0,510** [a] (0,185)	**-0,582** [a] (0,187)	**-0,532** [a] (0,202)
Education	**-0,469** [b] (0,196)	**-0,481** [b] (0,277)	0,491 (0,279)
Food and non-alcoholic beverages	**-0,549** [a] (0,150)	**-0,598** [a] (0,158)	**-0,852** [a] (0,297)
Furnishings and household equipment	**-0,420** [b] (0,188)	**-0,268** [b] (0,126)	-0,036 (0,119)
Health	**-0,140** [b] (0,064)	**-0,120** [c] (0,079)	0,185 (0,280)
Housing, water, electricity, gas	0,289 (0,255)	0,229 (0,234)	**-0,124** [c] (0,081)
Miscellaneous goods and services	-0,050 (0,077)	-0,041 (0,085)	-0,023 (0,191)
Recreation and culture	-0,047 (0,190)	-0,026 (0,185)	-0,016 (0,124)
Restaurants and hotels	-0,125 (0,130)	-0,124 (0,145)	**-0,271** [c] (0,312)
Transport	-0,097 (0,120)	-0,117 (0,106)	**-0,070** [c] (0,070)

[a]: significant at the 99% confidence level, [b]: significant at the 95% confidence level, [c]: significant at the 90% confidence level

In the case where Mediterranean countries are taken as benchmark, Greece converges to these countries' average in 6 expenditure shares (alcoholic beverages and tobacco, communications, food, housing, hotels and restaurants as well as transport). In fact, these categories of goods absorb 64% of Greek households' total consumption expenditure.

It now becomes obvious that, during the last 15 years, Greece's consumption pattern in certain categories of goods, tends to approach EU's average. This tendency intensifies when taking Mediterranean countries as benchmark. Our results become of more importance considering that during 1993-2007 Greece not only entered the euro zone but also organized the 2004 Olympic Games.

6 Conclusions

During the last 15 years, important changes have taken place in the structure of EU's as well as Greece's consumption pattern. Expenditure shares for certain categories of goods have greatly increased (communications and miscellaneous goods and services) while others have importantly decreased (food and household equipment). When examining the price levels for all goods, "housing/water/electricity/gas", "education" and "alcoholic beverages and tobacco" have shown the greatest increase, whereas the level of prices dropped in the case of "communications". Meanwhile, during the examined period, important developments have taken place, in the economic (high growth rates) as well as political (establishing euro zone) sphere.

In this context of changes, the present paper attempted to empirically investigate the convergence hypothesis of the consumption pattern as well as consumption's and consumption expenditure's determinants in EU, Greece and two sub-groups of countries (euro zone and Mediterranean countries). The empirical analysis shows that total consumption expenditure (as GDP percentage) diverges across EU-15 and euro zone while consumptions basic determinants have mostly appeared to, more or less, converge. Our results are similar when examining the case of Greece, where consumption as a whole diverges to EU's average but its determinants converge to those of EU countries.

Moreover, estimating σ-convergence showed that most of consumption expenditure shares tend to converge across the EU and euro zone. Results confirming convergence are even more impressive in the case of Mediterranean countries. As for Greece's consumption pattern, σ-convergence estimation showed strong tendency towards homogenization with the EU as well as Mediterranean countries. In fact, when comparing the Greek consumption pattern with the Mediterranean countries' average, consumption shares that converge represent 90% of total consumption expenditure.

In the course of this study, we have next moved on to econometrically cross checking Greece's consumption pattern convergence to that of the EU. Statistically important results occurred only in one category of goods (when choosing EU or euro zone as benchmark) and in two, when comparing Greece to Mediterranean countries. The number of statistically important results increases (to five and six respectively) when adding income and price level as control variables to the econometrical framework. This proves the decisive effect of these variables on the structure of consumption expenditure.

The hypothesis that consumption pattern convergence occurs across EU and Greece seems to be confirmed for certain categories of goods. Therefore, the general sense that, due to the European integration process and the expansion of new technologies, consumption patterns across EU tend to homogenize, is not empirically overruled on a first level analysis. It is, however, of particular importance to attempt further research and investigate on those factors that interpret the homogenization or differentiation tendencies across countries and consumption expenditure shares. In any case and beyond determinants deriving from economic theory, consumption expenditure and consumption patterns are also affected by other variables, linked to social values, preferences and, generally, each society's common features and culture.

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An empirical investigation of social protection expenditures on economic growth in Greece

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1. Introduction

The relationship between welfare state expenditures and economic performance has been a rather intriguing issue, not only for professional academics but for politicians as well. From the moment that the concept of welfare state comprises a field of class struggle and compromises, it is inevitable that every aspect of it will be engaged in all political debates. From an economist's side of view, the nexus of social policies aiming to alleviate income inequalities, poverty and social exclusion constitutes a variable capable to affect –in one way or another- economic performance. Especially, since after the Second World War, this "variable" has been obtaining a greater and greater significance, depicted in the tendency for increasing public expenditures as a percentage of GDP in western democracies.

This paper aspires to illuminate two phenomenally different issues which at the end seem to have a connection. The first one is to investigate the aggregate social expenditure trend and then its structure. The decomposition of aggregate social expenditures and the provision of qualitative evident regarding each social protection function are important in order to comprehend the weaknesses of the Greek social protection nexus. This is the topic of section 2. In section 3, this paper deal with an empirical investigation of the statistical relationship between the growth rate of the Greek economy to social protection expenditures. Despite the fact that the method used (OLS) is not technically the best one, we derive some statistical significant results, which can be interpreted under the light of the information drafted from Section 2. Namely, it is the nature and the structure of the social protection policies in Greece that are responsible for such a relationship between economic growth and social protection expenditures.

2. Social Expenditures in Greece (1980-2006)

The trend of aggregate social protection expenditures

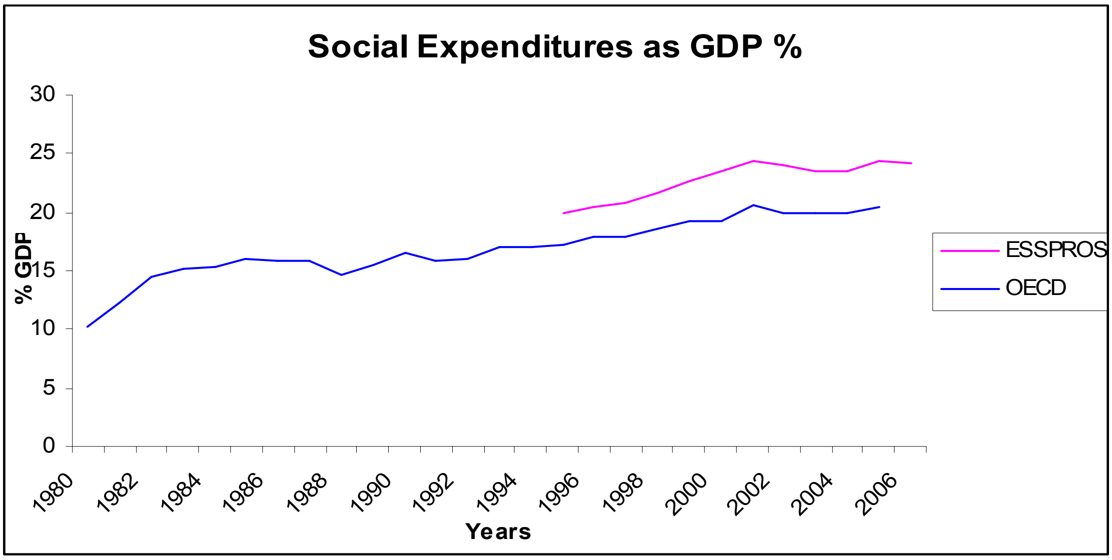
The study of aggregate social expenditure trends in Greece from the 1980s and afterwards may reveal a lot of characteristics of the Greek welfare state structure, but on the other hand it may conceal inequalities and injustices prevailing among different categories of the population or even within them. What is rather interesting is that despite the exogenous and endogenous constraints posed on the Greek economy, the general trend of social expenditure is increasing, although in a slower pace after the beginning of 1990s. The endogenous constraints could be summed up into the overwhelming public debt and deficits (beginning in the 1980s and continuing until present days), the double-digit inflation until the beginning of 1990s, the public sector enlargement which crowded out private investment and contributed to the accumulation of deficits and more. Exogenous constraints have been posed by the dynamics of globalization and the need to enhance competitiveness in a new international division of labor (Genschel; 2004), but mostly by the need for "Europeanization" (Featherstone; 2003); the adjustment of fiscal imbalances and the stabilization of inflation rates became a top priority, from the moment that the compliance with the Maastricht criteria became the unique goal of Greek economic policy in the mid-1990s. Therefore, social policy should be adjusted in the new conditions. Another important exogenous pressure was the predominance of neoliberal ideas in the political arena, which made their appearance in Greece one decade after they did in the Anglo-saxon world. The "welfare state retrenchment" (Pierson; 1996) has been one of the neoliberal dogmas that dominated economic and social policies in the US and Europe after the early 1980s.

As we mentioned above, the general trend of welfare state spending in Greece does not reveal such a "retrenchment". However, staying only to the aggregate data, it is not possible to illuminate structural changes in the Greek social policy that did, however, occur in these decades.

Moreover, it would be unwise not to count in the historical and social background of Greece entry in the 1980s. Until then, the Greek welfare state can be characterized as residual and rudimentary, while income inequalities and social exclusion were prevalent in the society. The radical shift in the political field, with the electoral victory of the socialdemocratic Panhellenic Socialistic Movement (PASOK) for first time in Greece's modern history (with the exception of a small interval in 1963-1965) inaugurated an extended implementation of social policy, covering the "non-privileged" parts of population. It is important to mention, that while the rest of "western" European countries developed a welfare state during the 1960s and 1970s, in the middle of the "golden age of capitalism", the Greek welfare state at that time remained stagnant and weak. It is a paradox that when the rest of the western European countries started rolling back their welfare states under the pressure of the economic crisis of the early 1980s (after the two oil shocks in the 70s), Greece's shift of political environment impelled an opposite trend; the development of welfare state in Greece was necessary at that time, but it had to encounter the "unlucky coincidence" of having to deal with a severe economic crisis.

As it is evident in Figure 1 social expenditures as a percent of GDP have grown substantially from 1980 to 2006. We use two sources of data, those of OECD covering the period 1980-2005 and those of Eurostat for social protection (ESSPROS), for the period 1990-2006. As it is obvious, there are discrepancies between the two series, but this seems quite logic, since the two organizations define social protection expenditures in a different manner. OECD data include only the expenditure on social protection made by the government and public organizations. Eurostat data, on the other hand, include both explicit and implicit expenditure, on benefits in kind and in cash, made not only by government and social insurance funds, but also by employers and other private entities, as well (Matsaganis; 2006, p.149, note). For this reason, Eurostat data exceed OECD data. However, we observe that the trend of social expenditures as a percentage of GDP is similar, independently of the source.

FIGURE 1



Sources: OECD database, 2009

ESSPROS-Eurostat database, 2009

According to the OECD data that cover the 1980s, we see that in 1980 the social protection expenditure were covering only the 10.2% of GDP, while between 1981 and 1982 we observe the highest increase, something that follows the succession of the conservative government of New Democracy (ND) by PASOK. At the end of the first term of PASOK in office (1981-1985), social expenditures had reached 16% of GDP, representing an increase by 57% as a percentage of the country's total output. During 1981-1985 and especially until the summer of 1982, PASOK exercised an expansionary income policy, targeting in narrowing wages inequality. As a result of this income policy (the introduction of ATA, a partial wage indexation scheme, constituted a significant such development), was that "earnings in the non-agricultural sector rose by 27% in 1982, that is 5.5% in real terms, while the increases in the manufacturing sector reached 37.5% ... (see OECD, 1983: 17-18)" as mentioned by Tsakalotos (1991).

However, in the second term in office, PASOK had to face serious macroeconomic imbalances and the failure of the heterodox economic policies of "gradual adjustment" and "stabilization through development". Since October 1985, PASOK makes a right turn in its economic policy, initiating a macroeconomic stabilization program. The main target was to reduce budget and external deficits and inflation, mainly through tighter income policies. This contractionary policy is reflected in the trend of aggregate social expenditures. From 16% in 1985, the spending on welfare state reduced at 14.6% (a 8.75% decrease) in 1988 and 15.5% in 1989 (a 3.12% decrease). But yet, the increase in 1981-1985 was so substantial that the decrease in social expenditures of 1985-1989 was impossible to overwhelm the rise of expenditures in the first term. Thus, while in 1980 social expenditures were estimated at 10.2% of GDP, in 1989 they were 15.5%.

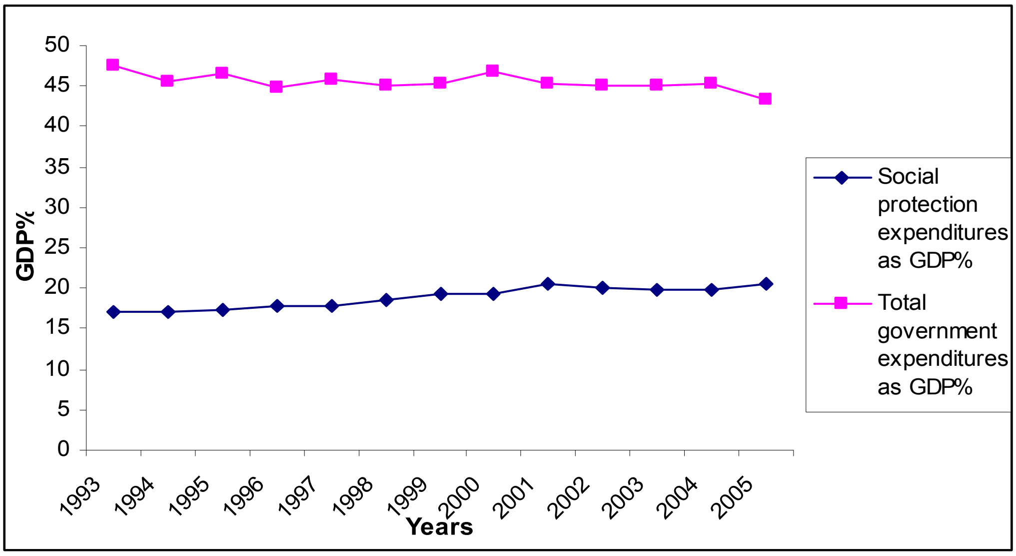
After a small interval of political instability in 1989-1990, New Democracy came into power in 1990 (a short-living government though, until 1993) launching a neoliberal economic program based on the two pillars of privatizations and liberalization of markets. The shrinking of public sector, the enforcement of competition, deflation and the decrease of deficits were the major goals of the newly elected right-wing government. Especially from 1992, the government pursued a bold economic policy, ensuring full liberalization of process, deregulation, tight control of government enterprises, social security reform, privatization and infrastructure investment (Alogoskoufis; 1995). This neoliberal economic policy could not have been reflected in the social policy arena; hence, looking at the data of social expenditures, we observe a significant fall during 1990-1991 in an attempt to "rationalize" public expenditures. In the same period, total government outlays fall substantially, not only as a reply to the hike of the previous year, but as a signal of the ND government's intention to cope with fiscal imbalances.

After 1993, PASOK regained the power and the country was placed on the track of compliance with Maastricht criteria. Until 2006 that exist available aggregate data for social protection expenditure in Greece however, there has been notified an undisrupted increasing trend. OECD and ESSPROS data agree both on this evolution of social protection layoffs. An interesting feature of the period 1993-2005 is that this increase in social expenditures did not coincide with the evolution of total government expenditure; while the latter is 47.55 of GDP in 1993, it diminishes to 42.2% in 2006 (AMECO-Eurostat database). In the table below, we see that there is a negative correlation and covariance between the time series of social protection expenditures and total government expenditure. Of course, there is no causal relationship for these negative results, but still it makes evident the magnitude of the different trends that these two expenditures followed in 1993-2005.

Table 1

Correlation and Covariance between social protection and total government expenditures as GDP % (1993-2005)	
Correlation Coefficient	-0,61567
Covariance	-0,76615

FIGURE 2



Sources: Government expenditures from AMECO-Eurotat database, 2009

Social protection expenditures by OECD database, 2009

This implies that the decrease in public expenditure was not generated in terms of cuttings in welfare state expenditure, but mostly through privatizations, shrinking the public sector and squeezing government consumption and investment. The most possible explanation for this increase in social protection spending is that the social conditions of Greek population were far behind comparing to the one of EU citizens. Unemployment remained high and always near 10% during all this period, while more than the 20% of households were below poverty threshold. Therefore, a decrease in welfare spending would have deteriorated this situation. However, an important issue is that these well-being conditions persist, despite the high level of spending in social protection, underlying the ineffectiveness of the Greek welfare state.

The structure of social protection expenditures

In this section we will focus on how social expenditures are structured in Greece and try to shed light on some issues that aggregate expenditure trends may not interpret. An important information arising from Matsaganis (2006), is that only the 16.3% of total benefits are non-contributory in 2001 and are financed by taxation (the National Health System is financed in this way). The rest 83.7% (2001) of total benefits is financed by employers', employees' and state contributions. Moreover, the 4.7% (2001) of total benefits are considered as means-tested benefits, meaning that they are awarded after a test of claimant's income. According to European Commission (2008), mean-tested benefits in Greece for 2005 were estimated at 7.8% of total benefits, while at the same time the EU-15 average was 10.7%. This social assistance benefits are a targeted policy to mitigate poverty, inequalities and social exclusion for very specific categories of population. However, this percentage is low comparing to the other countries of EU, although there is an increasing tendency. The countries with the highest percentage of means-tested benefits are mostly those of liberal welfare regimes (Ireland, UK) and those with the lowest are countries with socialdemocratic welfare states (Sweden, Denmark). Mean-tested benefits are opposed to the universality of social benefits which are the cornerstone of socialdemocratic welfare states, but since there exists a general tendency for the latter to water down some of its elements, it seems that there is an increasing trend for more benefits to be imposed to means tests.

Another distinction between social benefits is between those in cash and those in kind. According to OECD Glossary of Statistical Terms, social benefits in cash "consist of current transfers payable in cash to households by government units or non-profit institutions serving households ... to meet the same needs as social insurance benefits, but which are not made under a social insurance scheme incorporating social contributions and social insurance benefits". Benefits in kind, on the other hand, consist of individual goods and services provided as transfers in kind to individual households by government units (including social security funds) and non-profit institutions serving households.

At the table below, we can see the evolution of benefits in cash and benefits in kind in Greece from 1980 to 2005.

Table 2

Year	1980	1985	1990	1995	2000	2005
Benefits in cash	*471*	*2058*	*5.183,10*	*10332*	*17.226,60*	*26.646,20*
Benefits in kind	*229,7*	*892,1*	*1953,1*	*4.840,90*	*8.547,70*	*14.028,40*
Total	*700,7*	*2.978,70*	*7.217,40*	*15.529,40*	*26.105,00*	*40.807,30*
%of Benefits in cash in total	*67.2%*	*69%*	*71,8%*	*66,5%*	*66%*	*65,3%*

Source: OECD; Social Expenditures database, 2009

From European Commission (2008) data for 2005, we derive that the 65.6% of benefits in cash were not means-tested, while 34.4% were submitted in test of the resources of the claimants. From the benefits that were means-tested, the majority were benefits in kind (60.3%) and the rest were benefits in cash.

In Table 3, we see a decomposition of social expenditures as a percentage of GDP, based on data from OECD.

Table 3

	1980	1985	1990	1995	2000	2001	2002	2003	2004	2005
Old Age	*4,6*	*7,2*	*9,3*	*9,2*	*10,1*	*10,8*	*10,5*	*10,4*	*10,4*	*10,8*
Survivors	*0,8*	*1,5*	*0,5*	*0,5*	*0,8*	*0,8*	*0,8*	*0,8*	*0,8*	*0,8*
Incapability benefits	*1*	*1,8*	*1,2*	*0,8*	*0,9*	*0,9*	*0,9*	*0,9*	*0,9*	*0,9*
Health	*3,3*	*4,5*	*3,5*	*4,5*	*4,7*	*5,3*	*5,2*	*5,4*	*5,1*	*5,6*
Family	*0,3*	*0,3*	*0,7*	*1*	*1*	*1*	*1,1*	*1,1*	*1,1*	*1,1*
ALMP		*0,2*	*0,2*	*0,4*	*0,2*	*0,2*	*0,2*	*0,1*	*0,2*	*0,1*

Unemployment	*0,2*	*0,3*	*0,4*	*0,4*	*0,4*	*0,4*	*0,4*	*0,4*	*0,4*	*0,4*
Housing	*0,1*	*0,2*	*0,4*	*0,5*	*0,7*	*0,7*	*0,5*	*0,5*	*0,5*	*0,5*
Other	*0*	*0*	*0,1*	*0,1*	*0,3*	*0,4*	*0,3*	*0,3*	*0,4*	*0,4*
Total	***10,2***	***16***	***16,5***	***17,3***	***19,2***	***20,6***	***20***	***19,9***	***19,9***	***20,5***

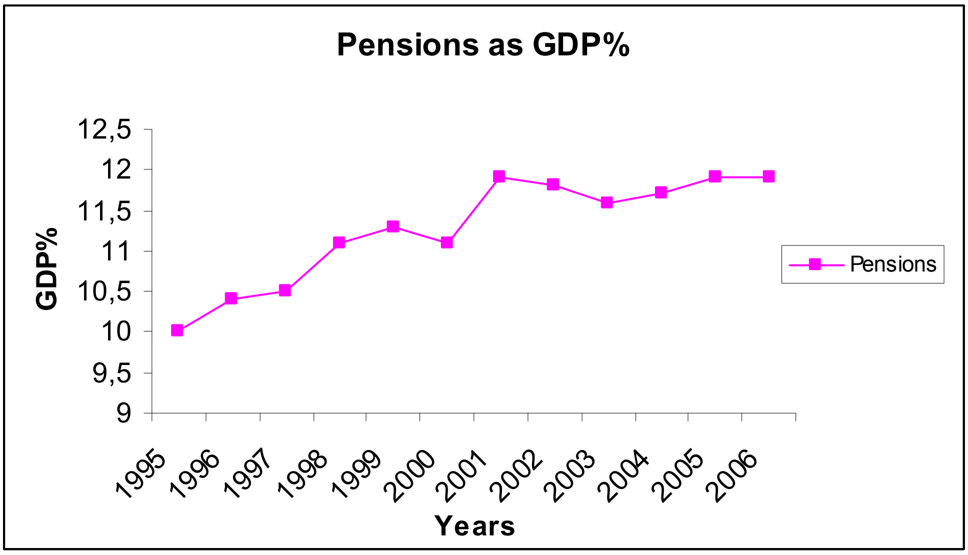
Source: OECD; Social Expenditures Database, 2009

It is evident from the first two rows ("old age" and "survivors"), which stand for pensions that the greatest part of social protection expenditures is channelled into pensions. The other significant sector of social protection, according to the data, is health serviced absorbing above 5% of GDP in the 2000s. Incapability benefits (some of which are considered as pensions), family allowances, unemployment benefits and housing comprise a very small part of the national product. An interesting element, is however the very small expenditure on active labour market policies (ALMP), despite the general trend after the beginning of the 1990s and mostly after OECD's Job Study in 1994 to use ALMPs as an instrument t increase employment and fight unemployment. The expenditures for ALMPs correspond to spending for training of unskilled workforce, subsidies to employers in order to increase labour demand and other policies offering incentives to individuals to raise labour supply.

Pensions

The social protection expenditures in Greece are based heavily on pensions. This is a typical characteristic of the continental/conservative welfare state regime (Esping-Andersen; 1994), which has been observed in a more intense manner in the southern European welfare regimes (Ferrera; 1996). The large majority of the welfare system relies on contributory and earnings-related benefits. Matsaganis (2006) estimates pensions to cover almost the 90% of total benefits in 2001, indicating that the system of social protection in Greece is strongly assiduous in this kind of transfer payments. From the data of the Social Budget (Ministry of Employment and Social Protection; 2006), we derive the conclusion that pensions are estimated in the 52.2% of the total Social Insurance (the latter including pensions, healthcare, welfare, administrative costs, property income expenditures and other expenditures). Exactly for this reason, we see that pension expenditures as a GDP% fluctuate in the same as aggregate social expenditures as GPD% do in Figure 1. A steady growth is observed, except for the period 1997-1998 and 2000-2001, were pensions increased significantly due to early retirement programs. In the period 2001-2003, a slight decrease takes place as a result of the attempt to balance fiscal deficits and solve social insurance problems.

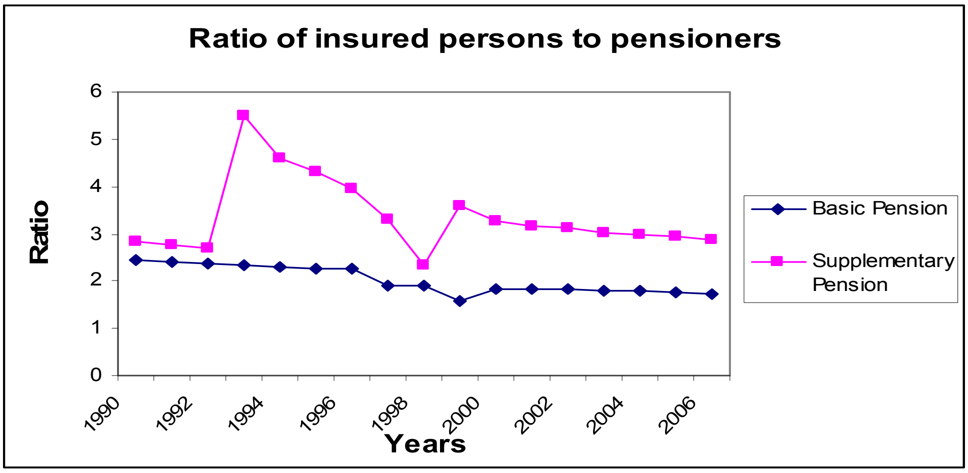
Figure 3



Source: ESSPROS-Eurostat database, 2009

A useful tool for studying the pension system imbalances is the ratio between insured people and pensioners. The lower this ratio is, the harder the demographic and fiscal problems for social insurance funds, since it implies that less persons should pay contributions for more people receiving benefits. The data are disappointing and are surely related to the high unemployment and its rather long duration (especially of young people), the contribution-evasion by firms and the early retirement programs. In the following graph we can see the evolution of this ratio from 1990 until 2006, for both basic and supplementary pensions.

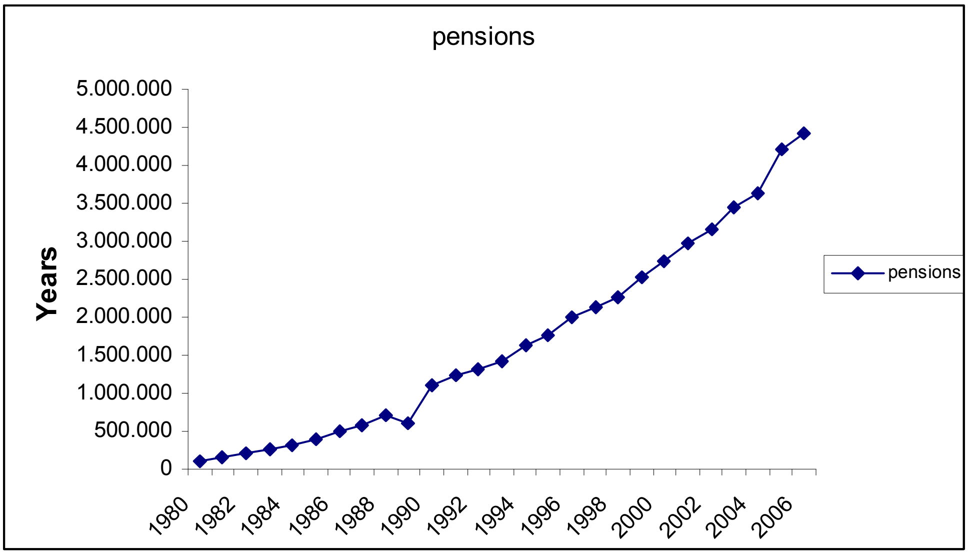
Figure 3



Source: Ministry of Employment and Social Insurance (2006)

At the following graph we observe the evolution of pension expenditures in mil. of euros from 1980 to 2006 (Ministry of Employment; 2008)

Figure 4



Source: Ministry of Employment; Social Budget 2008

At the beginning of 1980s, when the Panhellenic Socialist Movement (PASOK) took over its first term in office, pension expenditures increased sharply as a percentage of GDP. One of the first measures that the new government took was to raise significantly the lowest pensions, to incorporate to the social security system population groups that were in need but had never paid any contributions (such as the Greek repatriates from Eastern Europe and the Soviet Union) and to extend social security benefits to both rural and urban populations. Moreover, IKA that was since its establishment the main organization for carrying out social security policy absorbed a number of smaller, bankrupt funds that could not otherwise have survived. However, despite the rise in pensions that was remarkable for many professions, no structural change occurred in social policy. The social security system remained fragmented and although many categories of non-privileged citizens became better-off, inequalities in benefits even within the same profession, remained as a special feature. From the moment that the social security system in Greece comprises a PAYG scheme, any increase in benefits should be accompanied by a proportional increase in contributions; since, this proportionality was not maintained, it was inevitable to generate deficit problems to the funds. This fact, in combination to important demographic changes that were connected to the massive leave from the agricultural sector to the industrial one, deteriorated the already large deficits. Moreover, contribution evasion by private and also public corporations was regarded as an instrument to reduce the indirect labor cost and therefore was not encountered by the government.

One important explanation for this expansion of pension spending during that period was, according to Gravaris (2006), the employment policy to cope with unemployment issues throughout this stagflation era. The target of this policy was to reduce labor supply by increasing outflows from the labor market. An instrument for that was the relaxation of eligibility criteria, rendering retirement easier for some categories of the labor force. This relaxation of retirement terns was not equable among workers, but it was mostly enjoyed by these categories that could stress higher political pressure or were closer to the state apparatus. This policy on the one hand increased significantly the ratio of pensioners to workers and the spending for pension as a percentage of GDP, but at the same time it generated large inequalities in the social security system not only among different professions but also within the same professions. As Gravaris concludes "the distortions inflicted upon the social insurance system had not been caused by the generosity of the pensions that were actually paid but by the use of social insurance policy as a means of attaining the goals of a specific employment policy" (2006, p.61).

Entering the 1990s, the political setting changed rapidly. PASOK lost the elections after accusations for political and economic scandals and the conservative party of New Democracy (ND) came into power. At the same time, exogenous pressures especially from the European Community and secondarily by IMF and OECD, were imposed to the newly elected Greek government to cope with the huge budget deficits and the inefficiencies of the pension system.

ND government had to face the serious imbalances of the social insurance system. Two major laws were passed in the period 1990-1993 (Laws 1902/90 and 2084/92) targeting at the reduction of replacement rates, the curtailment of benefits especially for those entering labor market after 1/1/1993, the increase of contributions and the setting of 65 years old as the eligible retirement age both for men and women. The principle of reciprocity between benefits and contributions governed the logic of the reform; however, it led to severe social confrontations since it posed heavy weights on the shoulders of workers and the future generations of pensioners. More specifically, up to then minimum pensions were set as equal to the 80% of the day wage of an unskilled worker, namely the monthly minimum pension was equal to 20 day wages of an unskilled worker. With the 2084/92 law, this connection between wages and pensions was disrupted and minimum pension were estimated through an algorithm based on the average monthly GDP per capita of 1991. The result was that minimum pension after this law corresponded only to the 48.5% of the 20 day wages of unskilled workers!

The detrimental results of this reform with respect to benefits and contributions were concerning a very wide range of professions, especially those insured in IKA and the gap between low and high pensions grew significantly. In fact, the number of people increased dramatically by the middle of 1990s, while the same holds for pensioners living under the poverty threshold (Petmesidou, 1996). In this connection, a wide coalition was formulated among those with harmed interests, both workers and pensioners. Trade unions and pensioners' associations reacted to the reforms and the result was massive strikes and social upheaval. This attempt to reform the social insurance system generated a slightly positive fiscal outcome for the social insurance funds, but still left inefficiency problems untouched, while it impaired the social well-being of large parts of the population.

The ND government did not manage to complete its four year terms in office and 1993 PASOK was reelected; however until 1996, no major policies were taken up in terms of social issues. The year 1996 and the undertaking by Simitis of prime minister duties signified important changes in a range of policy areas. The concepts of "modernization" and "Europeanization" (Featherstone, 1998) became prevalent in the new government's rhetoric and significant reforms were planned in order to put Greek economy on the truck of convergence with the Maastricht criteria for entering the European Monetary Union. The first important measure taken was the establishment of a social solidarity allowance (EKAS) for the pensioners above 60 years old who where receiving a low pension. That was a non-contributory means-tested benefit, aiming to raise the income of a large part of pensioners who were living below the poverty threshold. According to Petmesidou (2000) and as mentioned in Venieris (2006, note 9), 70% of the pensioners in non-privileged funds were receiving a pension of 50% below the poverty threshold in Greece. This implies, that the implementation of EKAS was a rather radical policy, especially in country were social policy was mainly based in contributory schemes. In 1997, OGA was converted into a contributory social insurance fund, replacing the previous flat rate minimum pension for the part of population engaged in agriculture.

In 1998, a new law intended to regulate some fiscal and administrative difficulties encountered by some funds. For this reason, a number of similar funds were amalgamated or even if the case of amalgamation was not feasible, they were abolished. The most important amalgamation was the one of the self-employed workers social insurance fund (TEBE) with the one of merchants (TAE) and the one of public transport motor vehicle owners (TSA), giving birth to the Social Insurance Fund for Self-Employed Workers (OAEE), with 800.000 insured workers.

After a period of inactivity and a strikingly failed attempt for reform of the social insurance system in spring of 2001, the pressures from the European Commission towards the Greek government increased. For the European Commission, the pension system in Greece comprised a “bomb” in the foundation of the overall stabilization and developmental program and the convergence with the other EU members since “the stability of public economy in the long run, depends on the reconstruction of the social insurance system (in Venieris 2006, p. 84-85). The failed attempt to radically reform the pensions system in 2001 signified that an overall reform, rousing social conflicts, would be condemned to fail. A gradual adjustment to the EU prescriptions would be the only way to yield positive results.

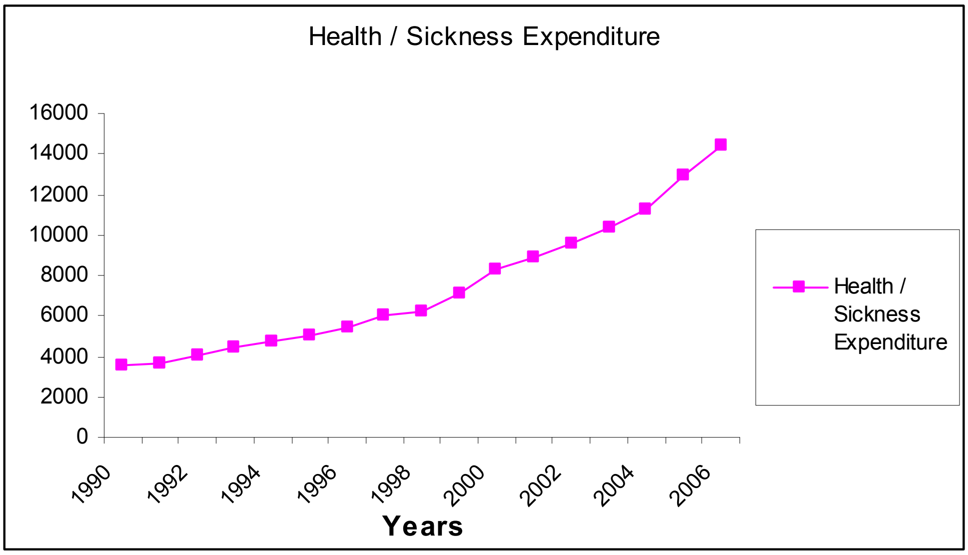
That was exactly what the 2002 reform in the pension system (Reppas Law) by PASOK government aimed. With this law, the state contribution to IKA (10% of total contributions) is abolished and is replaced by an annual subsidy of 1% of GDP. However, this subsidy is estimated much less than the previous contribution of the state in the context of the tripartite contributory system. Moreover, concerning the eligible retirement age, this law converted the 35 years of paying contributions to 37 for those insured after 1983 and set for both men and women that were firstly insured after 1993 the 65 years old as the eligible retirement age. This law, also, curtailed the early retirement for mother with minor children, by setting a common retirement age for all of them the 60 years old and 25 years of insurance, independently of when they were firstly insured. As far as it concerns the level of pensions, Reppas Law predicted that pensions should reach the 70% of pensionable income until 2017. However, as pensionable income this law considers the average income of the last 5 years of working (with the potential of choice among the best 5 years in the last 10 years). Furthermore, as a minimum pension was set the 70% of the minimum wage of a married full-time worker. Finally, the establishment of

Professional Insurance Funds is enacted, thus putting more weight to the second pillar of social insurance.

Health / Sickness Expenditures

Healthcare expenditures comprise a mostly in-kind benefit for most of the people and almost absolutely non-means-tested. Only 1128.9 mil. Euros out of the 14407.7 mil. in 2006 were corresponding to cash benefits, whereas the rest 13278.9 mil. were corresponding to benefits in kind. This is logic due to the nature of this function of social protection. Benefits regarding health are mostly hospital treatment and medicines, therefore it is expected that benefits in kind prevail. Moreover, the share of non-means-tested benefits reveals a crucial feature of the Greek healthcare system; only 30.9 mil. euros were absorbed for means-tested benefits, while the rest 14376.8 mil. were devoted to non-means-tested ones. This makes clear that on the contrary to the pension system which is a contributory-based one, the character of health care in Greece in universalistic and approximates a Beveridge-style system.

Figure 5

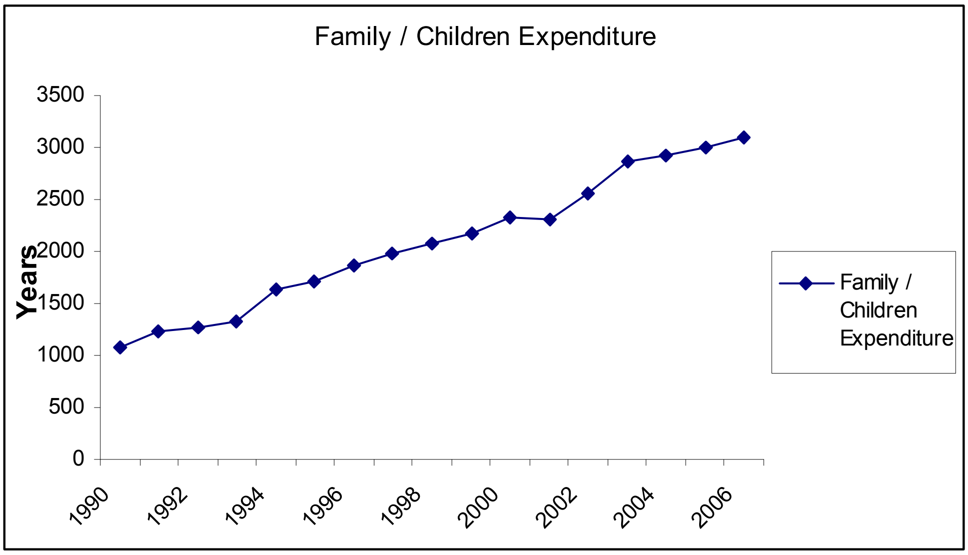


Family / Children Expenditures

Family and children allowances are consisted of non-contributory benefits and occupational family allowances (Matsaganis; 2006). Eligible people for receiving family allowances are all employed individual with children under the age of 18 or under 22 years old if they study. There are two sources for this benefits. The first one is the Greece Labor Force Employment Organization (OAED), through the Account for the Distribution of Family Allowances (DLOEM). This allowance is paid annually and is financed by employers' and employee's' contribution (1%each) (Davaki; 2006). The second one is through the Agricultural Insurance Organisation (OGA), and includes the so-called "lifetime-pension for mothers of many children", "the large family benefit" and the "third child benefit".

In the figure below, we can see the evolution of family expenditures from 1990 to 2006.

Figure 6



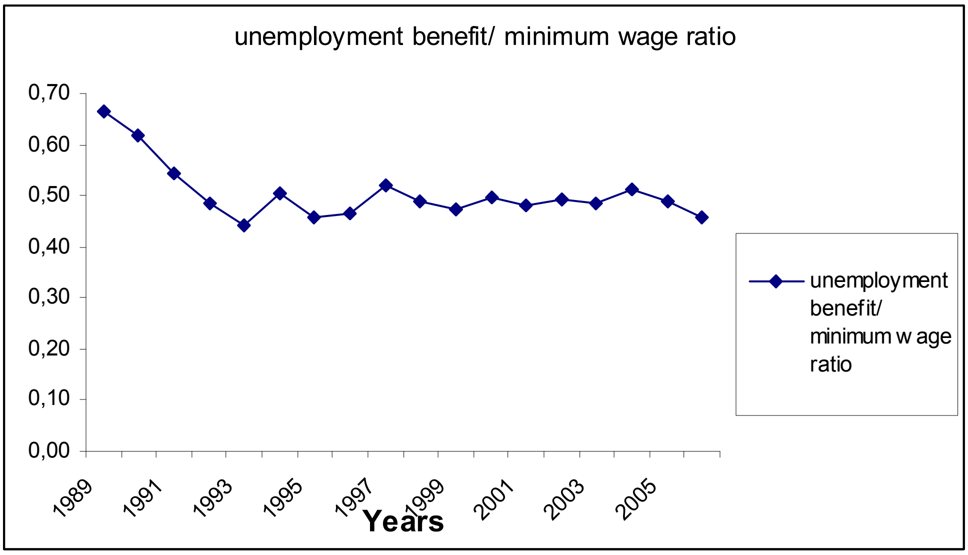
In the year 2006, until which there exist available data, these expenditures were estimated in 3.095 million Euros. From these, 2079.5 million were concerning cash benefits (1603.4 mil. were no-means tested and 476 mil. were means-tested) and 1015.6 million benefits in kind (out of which 479.6 mil. were means-tested and 539 mil. no-means-tested). Out of the total, 2139.4 million were not submitted in means-test and 955.6 mil. were means-tested.

The largest part of expenditures was channeled to family and children allowances (1.129 mil. or 36.5% of the total). Other important expenditures financed "child day care" (351.1 mil), the "income maintenance benefit in the event of child birth" (322.9 mil) and the "birth grant" (86 mil.).

Unemployment Expenditures

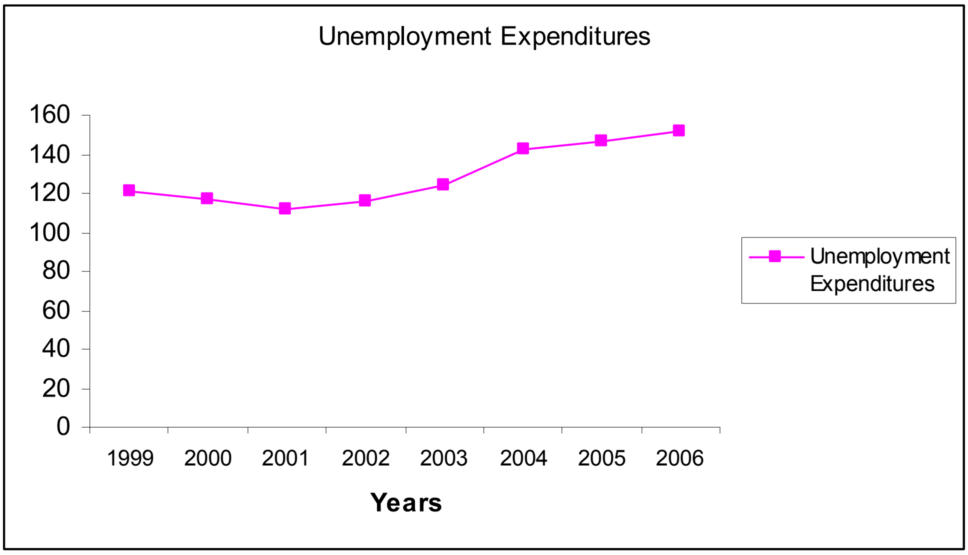
The social expenditure on the protection of unemployed are usually thought to be consisted mainly by unemployment benefits. Of course this is a large part of it but it is not the largest. It possesses a basic position however, since the "passive labor market policies" have a higher direct effect for the alleviation of the unemployed than ALMPs have. As the relationship of this kind of benefit with minimum wage has been strongly highlighted as a decisive factor of unemployment (OECD; 2004, Layard et al; 2006), the tendency is to try to diminish this ratio (replacement ratio). This is exactly what has taken place in the case of Greece after 1990. In the following graph, it is clear that the replacement ratio has followed a steadily decreasing trend, in an attempt to vanish labor market rigidities, in the cost however of the impoverishment of unemployed people.

Figure 7



In the following graph we see the evolution of expenditures for protection from unemployment. Despite the decrease until 2001, we see a keeping increase after that year. In 2006, the amount for this expenditure was estimated at 2.315,1 mil. The highest portion was corresponding to expenditures for vocational training (1122.4 mil. euros), while the full- and part-time unemployment benefit was estimated at 705 mil. euros, according to ESSPROS data.

Figure 9



3. Empirical Investigation of Social Expenditures' effect on Economic Growth

The object of this section is to try to investigate the relationship between social protection expenditures on the growth of the Greek economy for a period from 1988 to 2006. For this reason, we use regression analysis over a time series of data to test if the levels of aggregate social expenditures have a systematic effect on the GDP growth rate of Greece.

Variables

Gathering data for these variables was not an easy task. This is mostly due to the fact that the most well-known and often-used databases (i.e. OECD or IMF) do not contain long series of these variables; therefore, we resorted to the data of National Budgets of Greece by the Ministry of Finance, after making the necessary adjustments to correct from broken series, generated by the often revisions of the data.

Based on the empirical literature we use a model with six independent variables: private investment, government investment, social protection expenditures, trade balance, employment growth rate and government expenditures. The variables referring to expenditures, investment and trade are expressed as shares of GDP.

The *growth rate of employment* may be likely to generate a substantial part of economic growth. The sign however of this variable is not certain to be positive. The doubts on the sign arise from the fact that a high rate of employment growth may contribute to the lowering of capital-labor ratio (including both private and public infrastructural capital). Moreover, the sign of the effect of employment growth on GDP growth depends also on the skills of the new entrants in the labor market. If the skilled workers are proportionally more than the unskilled, then the GDP growth is expected to be positively influenced, whereas if unskilled workers are proportionally more, then the effect is ambiguous. It is important to distinct here employment growth from population growth, since the latter would reduce GDP per capita, although it could increase the size of labor force, allowing for economic growth, without tightening the labor market.

Private investment is a variable that could not have been omitted in a model interpreting GDP growth. The data used here refer to the ratio of private gross capital formation to GDP and are expected to have a positive effect on GDP growth.

Government investment may be another factor contributing to output growth, although smaller than private investment.

Total government expenditure over GDP is another independent variable used in order to proxy the public sector's size and its effect on economic growth. In order to avoid misspecification due to multicollinearity, the government capital formation and the share of social expenditures covered by the national budget[1] have been subtracted from total government expenditures. Estimating the relative size of the government in economic activity may be susceptible of a number of proxies. Many researchers (Landau; 1983, Romer; 1989, Easterly; 1990) have used the ratio of government consumption expenditures over GDP to estimate the public sector's size. However, here we will accept that the ratio of total government expenditures to GDP may perform better as a proxy of the share of public sector in economic activity (Levine and Renelt; 1992). As far as it concerns the sign of total government expenditures in the estimation model, this is ambiguous according to economic theory. Governments may provide growth-promoting public goods and design taxes to close the gap between private and social costs. Moreover, this kind of expenditures may be devoted to public utilities and infrastructures yielding increasing returns to

[1] The largest part of social protection expenditures is financed by semi-autonomous social insurance funds, which resources come mostly by the contribution of employers, employees and the state, in the context of the tripartite-contribution system. The healthcare expenditures are financed by the state through taxation. Moreover, after 1992 the state is obliged to support the budgets of social insurance funds. In general, the participation of the national budget in social expenditures is estimated at approximately 20% for 2006 (Ministry of Employment; 2006)

the economy. On the other hand, governments may waste funds, funnel resources to endeavours that do not encourage growth, and impose taxes and regulations that distort private decisions. Aggregate measures of government size will not capture the potentially important implications of how total government expenditures are allocated. Furthermore, even if government funds are always spent on growth promoting goods, there may be complex, non-linear tradeoffs between the beneficial effects of government services and the deleterious implications of distortionary taxes (Barro; 1990 and Easterly; 1990).

Trade balance as a percentage of GDP is another variable that we use. A large literature has emerged in the late 1980s and throughout the 1990s about the effect of economic openness on economic growth (Riviera-Batiz and Romer; 1990, Grossman and Helpman; 1991). International trade may generate proliferative positive results on growth, since except for being a factor affecting aggregate demand it may generate increasing returns to scale through technology transfer. The variable chosen to estimate the effect of trade on economic growth in this model is the net exports as a percentage of GDP.

The ratio of social expenditures to GDP is left as the last variable included in the model. This is actually the variable that we are interested in, since it may constitute an aggregate measure of welfare state. Despite some disagreements on whether quantifying the welfare state in terms of an expenditure variable is legitimate (Siegel; 2007), most of the studies include this independent variable as a proxy of the welfare state (Korpi; 1985, Friedland and Sanders; 1985, Castles and Dowrick; 1990). The sign of the coefficient estimate of social expenditures in this model cannot be predicted intuitively because these expenditures generate two opposite motions. The one enforcing the positive outcome on growth is based on a multitude of mechanisms. The first one is related to the effect that social expenditures impose on the disposable income. Social transfers in cash and kind increase households' income raising aggregate demand and thus yield a boosting push on total output. Moreover, social expenditures create a "safety net" towards risk; more specifically, policies that protect from exclusion and alleviate the cost of failures encourage the risk-taking necessary to engage in the inventive activity that leads to new ideas and new techniques of production. This would show up in the rate of technical progress, namely the total factor productivity growth, leading to increases of GDP growth rate (Atkinson; 1999). Another positive effect of social expenditures on economic growth stems from their effect on human capital. Social transfers improve the live quality of workers and thus increase their productivity. On the other hand, there is an opposite motion rendering the size of social expenditures a detrimental factor for output growth. This has to do firstly with the disincentives provided by welfare state mostly in terms of employment and savings (Lindbeck and Snower; 1986, Feldstein, 1974). Social expenditures such as unemployment benefits may increase the reservation wage for the outsiders of labour markets and therefore reduce labour supply and subsequently economic growth. Moreover, the payment of pay-as-you-go state pensions may reduce capital formation and hence the growth of output by an amount which depends on the growth rate of capital. Finally, social expenditures pose a heavy burden for the state budget and hence deepen fiscal deficits. The need to finance these deficits imposes to the government the purchase of bonds, which results in raising interest rates and thus in slowing-down economic activity (crowding-out effect).

Estimating the model

The equation that we want to estimate under the OLS method is the following

$$gdp\_gr = b_0 + b_1 * empl\_gr + b_2 * trade + b_3 * I^{pr} + b_4 * I^{g} + b_5 * govexp + b_6 * socexp$$

After running the first regression on STATA and testing for multicollinearity, heteroscedasticty, omitted variables, functional form and autocorrelation, it does seem that there exists a problem of autocorrelation, as it is expected since we encounter an estimation of a model with time series. More specifically, we present concisely the tests that we carried out.

First we carry out the variance inflation factor method to test for the severity of multicollinearity. A common rule of thumb is that if $VIF(b_i) \geq 5$ then multicollinearity is high and there exists serious problems for test hypotheses. However, other econometricians expand this rule of thumb up to $VIF(b_i) \geq 10$ (Kutner et al.; 2004). By accepting the most "flexible" rule of thumb, it appears that our variables do not face a problem of multicollinearity.

Variable	VIF	1/VIF
ipr	6.73	0.148588
socexp	5.84	0.171232
govexp	3.80	0.262820
trade	1.95	0.513053
ig	1.87	0.533715
empl_gr	1.21	0.827568
Mean VIF	3.56	

Then we perform the Breusch-Pagan / Cook-Weisberg test for heteroskedasticity with fitted values of the dependent variable. We are lucky to see that

$$Prob > chi2 = 0.0041$$

which implies that the we can reject the hypothesis that the variance of the error term is not constant in a 95% level of statistical significance.

As far as it concerns the "omitted-variables" test, we performed the Ramsey RESET test and we found that in a level of statistical significance 95%, the null hypothesis of "no omitted variables in the model" is accepted since

$$Prob > F = 0.0047$$

Now, concerning autocorrelation, a Breusch-Godfrey LM test was carried out and the following results were derived:

Breusch-Godfrey LM test for autocorrelation

lags(p)	chi2	df	Prob > chi2
1	0.007	1	0.9343

H0: no serial correlation

The null hypothesis is rejected since the p-value is very large. Therefore, we run a Prais-Winsten regression in order to derive BLUE estimates for the independent variables. The results of this regression are the following (p-values in brackets):

$$gdp\_gr = 4.63 + 0.36*empl\_rate + 0.11*trade + 0.44*I^{pr} - 0.08*I^{g} +$$

(0.02) (0.04) (0.08) (0.02) (0.45)

$$- 0.19*govexp - 0.31*socexp$$

(0.09) (0.04)

R-square = 0.6966

Adjusted R-square = 0.5146

Prob > F = 0.0302

d.f. = 13

Explaining the results

We observe that for a level of statistical significance 95%, the coefficients of trade, government expenditures and government investment are not statistical significant. However, trade and government expenditures are significant in a level of statistical significance 90%.

The insignificance of government investment seems rather surprising but there exists a possible explanation. Given the fact that private investment has a strong positive relationship with output growth, we can suppose that this insignificance of government investment suggests that its level is much smaller comparing to the private one (which is true) and that the returns of government investment are less important than those from private investment projects (which is also true it is considered that private sector's main criterion for investments is profits, whereas government may have other criteria, as well).

Government expenditures minus government investment and social protection expenditures (those aggravating the national budget) may fail to pass the 95% level of statistical significance, but it succeeds in the 90%. The important issue here is the negative sign of the estimated coefficient. This can be justified in the same manner as Dalamagas (2000) did for government consumption's effect on economic growth for Greece. An explanation can be that an increase in government consumption needs to be financed by more taxes and an increase in distortionary taxation will decrease growth. Moreover, an increase in government expenditure may not be complementary to private investment, but on the contrary it can generate a crowding-out of the private sector due to a higher income tax rate. This increase in taxes leaves individuals with less disposable income, thus decreasing the incentive to invest and work more.

Trade succeeds to be a statistical significant variable only in the 90% level of confidence. The negative sign of the coefficient implies that large trade deficits faced for years by the Greek economy weaken GDP growth as it is expected.

Private investment and the employment growth rate are statistical significant variables in a level of 95% and have positive effect on GDP growth, as it is expected.

Now, let us focus on the relationship between social expenditures and economic growth and try to derive some conclusions out of that. First of all, as it seems this relationship is statistical significant in a level of 95%. The important feature is the negative sign of the coefficient. It implies that for a 1% increase in social expenditures economic growth in Greece slows down by 0.31%. There may be several explanations for this outcome. The most usual is that social expenditures generate a heavy burden on the chronic fiscal imbalances, deteriorating this situation. This channel may destabilize the price level, raise the interest rates and create an unfriendly environment for private investments. If this effect is significant, it is very plausible to offset any positive result generated by social protection expenditures. This may be the case for the Greek economy.

However, this argument not only is superficial but it does not take account of the structure of social expenditures and the way that the Greek welfare state is organised. Of course, we should recognise that a more integrated analysis would require a decomposition of social expenditures in the model in order to test the relationship of every each one of them with economic growth. Such an analysis was not possible to be performed in this paper. Intuitively though, it can be argued that the negative relationship between social expenditures and economic growth is mostly due to the inefficiencies of the Greek welfare state, downgrading the positive effects it could have generated. Namely, it is not as much a matter of deteriorating fiscal imbalances as it is of the incapability of welfare state to ensure the challenging of poverty, income inequalities and social exclusion in Greece.

Let us try to be more specific and enforce the argument invoked above. As Papatheodorou and Petmesidou (2006) argue, pensions as a social transfer has a smaller effect on alleviating inequality than the rest of social transfers, although, as the authors notice, inequality does decline significantly because of them. This is explained because “pensions” are based on the employment background, the contributions that each employee has paid and the income that he has received during his employment. It is a reciprocal payment, not a redistributive one. The rest of social benefits though are non-contributory and are received by individuals independently of their employment background and their contributions. For this reason they tend to reduce inequality in a more effective way than pensions do. In

2001, according to the same study, the total social transfers in Greece contributed to a 28.7% decline of inequality (in terms of the Gini index), a percentage that was one of the lowest in the EU-15 (exceeding only Spain's and Portugal's). The reason for that is that the composition of social transfers is dominated by pensions (93.5% of the total social transfers in 2001) that exhibit a limited redistributive function comparing to the rest social transfers. Moreover, social transfers in Greece comparing to the rest of EU-15 are inefficient in reducing poverty, since the effect of social transfers on reducing poverty is the lowest together with Portugal (Heady et al.; 2003, Matsaganis et al.; 2002).

4. Conclusions

The aim of this paper was double. On the one hand to provide an image of the Greek welfare system through an analysis of social protection expenditures and on the other hand to attempt to estimate a relationship between these expenditures and Greek economy's growth. Social protection expenditures in Greece correspond to a relatively small part of GDP comparing to other countries of EU-15 (Greece exhibits a larger share of GDP only comparing to Spain, Portugal and Ireland). In 2006, the share of social protection expenditures in GDP was 24.2, while the EU-27 average was 26.9 and the EU-15 average was 27.5 (ESSPROS). A decomposition of aggregate social protection spending indicates that pensions absorb the largest part of this share. By examining some qualitative fact concerning the social insurance system in Greece, we saw that it is fragmented and dominated by clientilistic practices; therefore it promotes injustices and inequalities, even within the same profession. The fact that social protection expenditures are negatively related to economic growth, in our point of view, reflects these inefficiencies of the Greek welfare system. Fiscal imbalances were existent even when social protection expenditures were a very small fraction of GDP and consequently it would be unwise to blame a residual welfare state for these.

In this context, what is necessary is not a retrenchment of the Greek welfare state but a reform of it. Social protection expenditures should be planned in such a way targeting income inequality, poverty and social exclusion. We strongly believe that if this will be the case then they may have a positive effect on economic growth.

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