The Southeuropean Review of Business Finance & Accounting ©

Published semiannually Volume 8, June & December 2010

Department of Accounting
of the Technological Educational Institute of Piraeus

The Southeuropean Review of Business Finance & Accounting ©

The Southeuropean Review of Business Finance & Accounting ©

Published semiannually

Volume 8, June & December 2010

Department of Accounting
of The Technological Education Institute of Piraeus

THE LONG MEMORY PROPERTY OF STOCK MARKET RETURNS: EVIDENCE FROM THE ATHENS STOCK EXCHANGE

Panagiotis Arsenos**, Leonidas Zarangas**

Abstract

This study provides empirical evidence of the long-range dependence in the returns and volatility of Greek Stock Market (ASE). We test for long memory in the daily returns and volatility series using both parametric (GARCH, FIGARCH) and non parametric methods. Significant long memory is conclusively demonstrated in the volatility measures, while there is a little evidence of long memory in the returns themselves. This evidence disputes the hypothesis of market efficiency and therefore implies fractal structure in the emerging Greek Stock Market. We conclude that stock market dynamics in this emerging market, even with its different institutions and information flows than the developed market, present similar return-generating process to the preponderance of studies employing other data. Our results should be useful to regulators, practitioners and derivative market participants, whose success depends on the ability to forecast stock price movements.

JEL Classification: C22, G1,G11, G12, G13,G15
Keywords: Volatility Models; long memory; fractional integration; stock market index

---

* Technological Educational Institute of of Ionian Islands, GR-31100, Kefalonia, Greece.
Corresponding author. E-mail: parsenos@gmail.com

** Technological Educational Institute of Epirus, GR-48100, Preveza, Greece.

The authors would like to thank without implicating Dimitris Georgoutsos, George Kouretas and an anonymous referee for many helpful comments and discussions.

1. Introduction

Over the past 20 years, volatility in financial markets has attracted growing attention by academic researchers, policy makers and practitioners. First, volatility receives a great deal of concern from policy makers and financial market participants because it can be used as a measurement of risk, providing an important input for portfolio management, option pricing and market regulation (Poon and Granger, 2003). Second, greater volatility in the stock, bond and foreign exchange markets raises important public policy issues about the stability of financial markets and the impact of volatility on the economy. High volatility beyond a certain threshold will increase the risk of investor losses and raise concerns about the stability of the market and the wider economy (Yu, 2002; Cote, 1994; Bernanke and Gertler, 1999). Third, from a theoretical perspective, volatility plays a central role in the pricing of derivative securities, and according to the Black-Scholes formula, volatility is the only parameter that needs to be estimated.

Volatility persistence is a subject that has been investigated thoroughly for developed markets. The extent of volatility persistence depends on the long-term dependence known as long memory of asset returns. The presence of long memory in asset returns is contradicting with the weak form of the Efficiency Market Hypothesis, which states that future asset returns are unpredictable from historical returns.

A finding of long memory in asset returns calls into question linear modelling and invites the development of nonlinear pricing models at the theoretical level to account for long memory behaviour. Mandelbrot (1971) observes that in the presence of long memory, the arrival of new market information cannot be fully arbitraged away and martingale models of asset prices cannot be obtained from arbitrage. If the underlying continuous stochastic processes of asset returns exhibit long memory, then the pricing derivatives by martingale models may not be appropriate as well as statistical inference concerning asset pricing models based on standard testing procedures (Yajima, 1985). Due to the theoretical and empirical importance of the issue, there is an extensive literature on analysing the long memory properties of financial asset returns in major financial markets. Earlier studies that analyse presence of long memory in developed stock markets using different methodologies of estimations varieties and frequencies of data showed that international markets of stock returns confirm presence of long memory in the conditional volatility process of financial asset returns (Lo, 1991; Ding et al., 1993; Crato 1994; Cheung and Lai 1995; Bollerslev and Mikkelsen,1996; Lobato and Sevin,1998; Cheung, 1993; Chou and Shih,1997; Helms, Kaen, and Rosenman, 1984; Kao and Ma (1992); Eldridge, Bernhardt, and Mulvey (1993); Fang, Lai, and Lai (1994), and Corazza, Malliaris, and Nardelli (1997); Greene and Fielitz (1977); Nawrocki (1995) Jacobsen (1996); Cheung, Lai, and Lai (1993). The evidence provided by these studies is more or less expected as testing efficient market hypothesis for international markets resulted in accepting the null hypothesis of such markets are weakly and/ or semi-strong efficient.

Despite the extensive research into the empirical and theoretical aspects of this relation in the well-developed capital markets, usually the U.S. markets, which are highly efficient in terms of the speed of information reaching all traders, little is known about the information interaction in emerging securities markets. Emerging markets differ from developed markets as the former in most cases characterized by lack of institutional development, thinly traded markets, lack of corporate governance, market microstructure distortions that hinder the flow of information to market participants and more volatile than well known world financial markets (Domowitz, Glen, and Madhavan (1998)). Further, the industrial organization found in emerging economies is often quite different from that in developed economies. All of these conditions and others may contribute to a different dynamics underlying returns and volatility in Emerging Capital Markets. Recent research on Emerging Capital Markets has shown presence of long memory in asset returns (e.g., Kilic, 2004; Barkoulas et al., 2000; Sadique and Silvapulle, 2001). These studies report that emerging capital markets exhibit higher average returns as well as higher volatility.

This paper will focus on the Greek Stock Market (ASE, henceforth) revisiting the issue of volatility persistence in stock market returns. Previously, Barkoulas *et al.,* (2000) report evidence of long memory in the conditional mean of weekly Athens stock index returns, a finding contrary to the results from developed stock markets.

The paper will attempt to investigate empirically market returns volatility persistence in a distinct approach from previous researches by testing for presence of fractional dynamics i.e. long memory in ASE's returns. Specifically, the paper tries to answer the following question. Does daily ASE stock price index returns have *long memory* property, with index returns being approximately uncorrelated, with very persistent autocorrelation in squared and absolute returns? To answer this question we employ in this study the Fractionally Integrated Generalized Autoregressive Conditional Heteroscedasticity (FIGARCH) model proposed by Baillie et al. (1996). In order to better assess the presence of long memory in the volatility of index returns, this paper also provides evidence of long memory in absolute and squared returns from a number of alternative methods, particularly, the GPH estimator due to Geweke and Porter-Hudak (1983). The findings of the paper indicate presence of long memory in the volatility process of ASE stock index returns. Contrary to empirical evidence on some other Emerging Capital Markets, conditional mean of ASE stock index daily returns do not posses long memory component.

The remainder of the paper is organized as follows. The next section after giving a brief overview of the Greek Stock Market environment describes the data and gives preliminary evidence on long memory. The third section briefly describes various competing volatility models and methodology used in the study. The fourth section presents the results and their interpretations. The final section summarizes the findings and indicates scope for further research.

2. The Greek Stock Exchange Environment – The Athens Stock Exchange

The Athens Stock Exchange is the primary stock market in Greece. It is a small emerging capital market established in 1876 when issuance of the first Stock Exchange Law was introduced based on the French Commercial Code. The exchange began to operate as a self regulated public institution.[1] In 1988 Law 1806 introduced new concepts in stock exchange function and regulation. It provided the legal framework for the establishment of the Parallel Market and the Central Securities Depository. It enlarged the Stock Exchange Board of Directors and modernized the exchange. Today the Athens Stock Exchange S.A. is a joint company, supervised by the minister of National Economy. Trades are conducted electronically through the Automated Trade System. Stock exchange representatives, who are supplied with code numbers for that purpose, en-

[1] For more information on the evolution of the legislation towarads today's format you may check ASE's web page at www.ase.gr.

ter orders into the system. The main index is the ASE General Price Index. The positive performance of the Greek Capital Market in the last few years has led international organizations to create indices for the close monitoring of the market. Apart from the general index, the ASE computes a number of indices with the aim of providing investors with reliable points of reference for the market's performance. In addition, indices are used in the development of derivatives and other financial products traded in the Athens Derivative Exchange (ADEX). The main indices calculated by the ASE are: the three FTSE/ASE indices (20 Index, Mid 40 Index, Small Cap 80 Index), the ASE Composite Index of the Main Market, the ASE Composite Index of the Parallel Market, the ASE sector indices, the All-Share Index and the two (Main-Parallel) total return indices.

The FTSE/ASE 20 index includes the 20 shares with the highest capitalization traded in the ASE and is the first index that has been used as the underlying instrument for futures and options traded in the ADEX. FTSE/ASE 20 stock index options were launched in ADEX in the beginning of September 2000. These are European type calls and put options contracts guaranteed by the Athens Derivative Clearing House (ADECH).

The range of derivative products traded in ADEX expanded during 2001 and 2002, giving the ability to investors to choose from a variety of products such as index futures and options on the FTSE/ASE 20 as well as on the FTSE/ASE Mid 40, stock futures on major Greek stocks with physical delivery on expiration and Stock Repo/Reverse Repo contracts. The latter presents an innovative traded approach to stock lending and borrowing for all market participants.

Though the Greek stock market is rather small by international standards, it has grown considerably. Since the late 1980s, the institutional setting is being liberalized with technical changes, which are aimed at improving the overall workings of the market. The major changes, by way of legal provisions, namely Law 1806 and Law 1969, provided the legal framework for the establishment of the Parallel Market and the Central Securities Depository, and paved the way for the modernization of the ASE.[2] Other changes in this direction consisted of the introduction of

---

2 This also included the creation of a capital committee, whose remit also include the expulsion of firms from the exchange, the approval of issuance of new securities, and decisions on the appointment of new brokers.

brokerage companies, the clear delineation of their rights and obligations, tighter systems of management controls, stricter monitoring against insider dealing, and the introduction in 1992 of the Automated Exchange Trade System (AETS).[3]

Much of the attention that domestic as well as foreign investors have shown for the Greek Stock Exchange Market is because of the performance of the Greek Economy for the last five years. Economic fundamentals drove foreign investors to select ASE as part of their portfolio, towards diversification and reduction of systematic risk, giving a boost to ASE and from 932.00 points that was in January 1990, reached 2263.58 on December 2003. Table 1 shows the yearly returns of the ASE General Price Index and FTSE/ASE 20 from the end of 1990 to 2003.

However it is noted that the market faced some very high volatile periods, where uncertainty, speculation characteristics and erratic and sometimes unjustifiable price swings took place.

From the above discussion, it is evident that, like most emerging capital markets, the ASE has many characteristics found in developing economies. It is relatively thin (with low trading volume) and is subject to non-synchronous trading resulting from the periodic trading by individual 'agents', largely as a result of information, decision, and transaction costs.[4] The question, however, to both foreign investors and to the local economy is whether the changes taking place have a significant impact on the efficient functioning[5] of the ASE.

---

3 Prior to the induction of AETS trading in shares operated through an open outcry system. Also, the market saw the establishment of 8% and 4% price limits for the more and less actively traded stocks, respectively. Recent developments in the financial markets have seen the widening of price limits to 10% and the introduction of new investment instruments in the form of futures contacts.

4 These problems are, in main, a consequence of non-synchronous price behavior in the Greek stock market, due to the ASE trading mechanisms.

5 An efficient market facilitates the allocation of scarce capital resources and the ensuing economic progress.

3. Modelling Persistence and Volatility Clustering

3.1 Model Framework

A class of parametric models that is capable of modelling volatility clustering is the GARCH model of Bollerslev (1986). The GARCH(p, q) process is defined by

$$\varepsilon_t = z_t \sigma_t$$
$$\sigma_t^2 = \omega + \sum_{j=1}^{q} \alpha_j \varepsilon_{t-j}^2 + \sum_{j=1}^{p} \beta_j \sigma_{t-j}^2$$

Using the lag or backshift operator L, the GARCH(p, q) model is:

$$\sigma_t^2 = \omega + \alpha(L)\varepsilon_t^2 + \beta(L)\sigma_t^2 \quad (1)$$

where z_t is i.i.d. with $E(z_t) = 0$ and $Var(z_t) = 1$, μ_t can be any appropriate regression model for the conditional mean of the process, $\alpha(L)$ and $\beta(L)$ are the lag polynomials of order q and p. The GARCH(p, q) model is covariance stationary if all the roots of $1 - \alpha(L) - \beta(L)$ lie outside the unit circle. In the GARCH(p, q) model, current conditional variance is parameterised to depend upon q lags of the squared error and p lags of conditional variance. For example, if $p = 1$ and $q = 1$ the current conditional variance will be influenced by past information from the pervious periods. Thus, this model postulates the common phenomenon of stock volatility that large returns are expected to follow large returns, and small returns to follow small returns.

GARCH models are able to describe certain properties of economic time series, such as volatility clustering and excess kurtosis. Despite the advantage for measuring volatility clustering, one of the major drawbacks GARCH models have in asset pricing applications is that the GARCH model is a short memory model as a volatility shock decays at a fast geometric rate and it is unable to capture the persistence of the effects of shocks in the volatility process. (Nelson,1991; Bollerslev, Chou, and Kroner, 1992) As we have seen previously, sample autocorrelations of certain volatility measures, such as absolute and squared returns, decline at a hyperbolic rate. Standard GARCH models fail to account this slow decay in the autocorrelations. In applications of GARCH (1, 1) model to the high frequency economic and financial data, it is usually found that the estimates of α_1 and β_1 are such that their sum is close to or equal to 1.

To take account of a unit root in the autoregressive polynomial $[1 - \alpha(L) - \beta(L)]$, Engle and Bollerslev (1986) introduced the IGARCH model. The reason is that the restriction on these parameters leads to a unit root in the ARMA (1, 1) representation of GARCH (1, 1) model. The properties of the conditional variance ht as implied by the IGARCH model are not very attractive from an empirical point of view. The IGARCH model implies that a shock to the volatility process will have very persistent effects. The IGARCH (p, q) process is given by

$$\phi(L)(1 - L)\varepsilon_t^2 = \omega + [1 - \beta(L)]\nu_t \tag{2}$$

where $\phi(L) = [1 - \alpha(L) - \beta(L)](1 - L)^{-1}$. In the IGARCH process, current information remains important for the forecast of the conditional variance for all horizons.

Baillie, et al. (1996) proposes the class of FIGARCH models. The FIGARCH process is capable of modelling very slow hyperbolic decay in the autocorrelations of the volatility process together with the volatility clustering phenomenon quite flexibly. Similar to the ARFIMA process for the mean by Granger and Joyeux (1980), the FIGARCH process can be obtained by extending Eq. (2). A FIGARCH process of order (p, d, q) is defined by

$$\phi(L)(1 - L)^d\varepsilon_t^2 = \omega + [1 - \beta(L)]\nu_t \tag{3}$$

where $\phi(L) = \omega[1 - \beta(L) - \alpha(L)]$, all the roots of of $\phi(L)$ and $[1 \ \ - \beta(L \ \ )]$ lie outside the unit circle, $\nu_t \equiv \varepsilon_t^2 - \sigma_t^2$ and $0 < d < 1$. For $0 < d < 1$, $\phi(L)$ is an infinite order polynomial. In Eq. (3), persistence of shocks to the conditional variance, or the degree of long-term dependencies is measured by the fractional differencing parameter d. The FIGARCH model provides greater flexibility for modeling the conditional variance as it accommodates the covariance stationary GARCH model when $d = 0$ and the IGARCH model when $d = 1$ as special cases. For the FIGARCH model in equation (10) the persistence of shocks to the conditional variance, or the degree of long memory is measured by the fractional differencing parameter d. Thus, the attraction of the FIGARCH model is that for $0 < d < 1$, it is sufficiently flexible to allow for intermediate range of persistence.

3.2 Model Specification and Estimation

As the simplest case, we choose the FIGARCH (1, d, 0) model to investigate the long memory property of volatility of stock index returns. Previous studies using the GARCH(p, q) model show that most financial time series are well modelled by the low order of (1, 1). The model specification is the following:

$$R_t = \mu + \varepsilon_t \tag{4}$$

$$\varepsilon_t = \sigma_t z_t,\, z_t \sim N(0,1), \varepsilon_t/\Psi_{t-1} \sim N(0,\sigma_t^2) \tag{5}$$

$$\phi(L)(1-L)^d \varepsilon_t^2 = \omega + [1-\beta(L)]\nu_t \tag{6}$$

In the previous three equations: R_t is the stock return at time t, defined by $100 * \ln(P_t/P_{t-1})$ and P_t is the stock price at t; Ψ_{t-1} is the information set at time $t-1$; and, $\phi(L)$ and $\beta(L)$ are lag polynomials of order 0 and 1, respectively. As an alternative representation for the FIGARCH model Eq. (6) can then be rewritten as:

$$[1-\beta(L)]\sigma_t^2 = \omega + \left[1-\beta(L)-\phi(L)(1-L)^d\right]\varepsilon_t^2 \tag{7}$$

From this representation, the conditional variance of ε_t^2, or infinite ARCH representation of FIGARCH process, is simply obtained to be

$$\begin{aligned} \sigma_t &= \frac{\omega}{1-\beta(1)} + \left[1 - \frac{\phi(L)}{1-\beta(L)}(1-L)^d\right]\varepsilon_t^2 \\ &\equiv \frac{\omega}{1-\beta(1)} + \lambda(L)\varepsilon_t^2 \end{aligned} \tag{8}$$

where $\lambda(L) = \lambda_1(L) + \lambda_2(L) + ...$ For the FIGARCH(p, d, q) process to be well defined and the conditional variance to be positive for all t, all the coefficients in the infinite ARCH representation in Eq. (8) need to be nonnegative, i.e. $\lambda_j \geq 0$ for $j = 1, 2, \ldots$ The general conditions for nonnega-tivity of lag coefficients in $\lambda(L)$ are not easy to establish, but as illustrated in Baillie et al. (1996) it is possible to show sufficient conditions in a case by case basis. For $0 < d < 1$, $\lambda_1 = 0$, the second moment of the unconditional distribution of $\varepsilon_t$is infinite, and hence, similar to an IGARCH process, FIGARCH process is not covariance stationary. As argued in Baillie et al. (1996), just like the IGARCH processes, it can be shown that FIGARCH processes are strictly stationary and argotic for $0 < d < 1$. The FIGARCH process implies a slow hyperbolic rate of decay for the autocorrelations of ε_t^2 , which is a characteristic of long memory processes.

Under the assumption of conditional Gaussian errors, the most common approach for estimating ARCH class models is to maximise a conditional likelihood function,

$$\log(L_{norm}) = -\frac{1}{2}T\log(2\pi) - \frac{1}{2}\sum_{t=1}^{T}\left[\log(\sigma_t^2) + \frac{\varepsilon_t^2}{\sigma_t^2}\right] \tag{9}$$

Since the ASE General price index return series are not well described by the conditional normal distribution, subsequent inference is consequently based on the Quasi Maximum Likelihood Estimation (QMLE) technique of Bollerslev and Wooldridge (1992).

$$T^{1/2}\left(\hat{\theta}_r - \theta_0\right) \rightarrow N\left\{0, A(\theta_0)^{-1}A(\theta_0)^{-1}\right\} \tag{10}$$

where $\hat{\theta}_r$ based on T is consistent and asymptotically normally distributed, and θ_0 denotes the true parameter values. $A(\bullet)$ and $B(\bullet)$ represent the Hessian and outer product gradients, respectively. Bollerslev and Wooldridge (1992) and Lee and Hansen (1994) showed that the QMLE estimators obtained under the normality assumption is consistent if the conditional mean and the conditional variance are correctly specified. Baillie et al., (1996) and Baillie et al., (2001) have shown by simulation the consistency and asymptotic normality of QMLE for FIGARCH (p, d, q). For details, see Baillie et al. (1996).

Another important concern is that the estimation of FIGARCH model requires the minimum number of observations. This minimum number is related to the truncation order of the fractional differencing operators $(1-L)^d$ for the FIGARCH (p, d, q), model in Equation (10). Following the standard procedure in the literature, the truncation order of the infinite $(1-L)^d$ is required to use a sufficiently high 1000 lags because of the positive value of d.

The long memory parameter of squared and absolute returns are estimated by using the log-periodogram regression estimator proposed by Geweke and Portar-Hudak (GPH, 1983) a local Whittle estimator as suggested by Fox and Taqque (1986).

GPH method is a semi-parametric procedure to obtain an estimate of the fractional differencing parameter d based on the slope of the spectral density function around the angular frequency. The procedure is based on the slope of the spectral density function, where $I(\xi)$ be the periodogram of y at frequency ξdefined by

$$I(\xi) = \frac{1}{2\pi T}\left|\sum_{t=1}^{T} e^{it\xi}(y_t - \bar{y}\right|^2 \tag{11}$$

4. Empirical Results

4.1 Data and preliminary evidence on long memory

The data set we will analyze in this paper is the daily closings of the ASE stock market price index and the sample period and the sample period is 20 June 2000 when the official announcement of Greece joining the European and Monetary Union was made, to 8 February 2007 for a total of 1660 observations.

In order to avoid the problem of non-stationarity which is a well known feature of the stock price series, it is necessary to make use of first - (or higher) differentiated data. To examine, whether the general index series are stationary, we apply the Augmented Dickey-Fuller (ADF) and Phillips and Perron (1988) (PP)test for the null hypothesis of a unit root against the alternative of stationarity of the ASE stock price index series. The results of the unit root tests are presented in Table 1. Both of the tests indicate the presence of unit root in the logarithm of P_t. The two tests fail to reject the null of unit root in the 1% significance level for the logarithm of the daily pricesP_t. For the logarithmic first differences R_t there is strong evidence of no unit root. The calculated sample values of the ADF and PP statistics reject the null of unit root in the 1% significance level. Given the results of this preliminary analysis we will focus on the continuously compounded percentage index return per day $R_t = 100 * (\log P_t - \log P_{t-1})$, which corresponds to the approximate percentage nominal return on the index obtained from time t *to* $t-1$. The realized volatility is measured as square of the daily index return (Gokcan, 2000). Let R_t, V_t^2 and $|R_t|$ denote respectively the closing index value, the realized volatility of index return and absolute return at period t. Since daily returns usually have mean close to zero, the absolute return is sometimes used as a measure of volatility. To test whether the daily realized volatility series is stationary, the ADF and the PP statistics are calculated using the entire sample and the data do not support the unit root null hypothesis at 1% level. Similarly, it is observed that the absolute return $|R_t|$ series are also stationary.

Table 1 reports several preliminary statistics for daily ASE stock price index. We can see from Table 1 that the kurtosis of R_t of 6.99 is higher than the normal distribution which is 3. The kurtosis shows the characteristic "fat-tailed" behavior compared

Table 1: Preliminary statistics for $LogP_t$, R_t, V_t^2 and $|R_t|$ series

Statistics	$LogP_t$	R_t	V_t^2	$\|R_t\|$
Mean	7.921831	0.005364	1.673486	0.927452
Median	7.898474	0.003791	0.469626	0.685293
Maximum	8.476898	7.620454	64.93951	8.058506
Minimum	7.291179	−8.058506	3.27E-07	0.000572
Std. Dev.	0.277985	1.294012	4.097622	0.902113
Skewness	−0.045868	0.040263	7.432313	2.383530
Kurtosis	2.084492	6.991276	82.31022	12.33241
D-statistic	0.064549*	0.053036*	0.341489*	0.152103*
J-B	58.51914	1101.629	450077.5	7591.217
Probability	0.000000	0.000000	0.000000	0.000000
$Q(20)$	31284.9	41.7629	507.278	565.634
$Q^2(20)$	31235.6	507.278	143.583	507.278
ARCH-Test	24.586*			
Unit Root test statistics				
Dickey-Fuller(ADF)	−0.7268	−37.3390*	−12.7091*	−11.6892*
Phillips-Perron(PP)	−0.8271	−37.5529*	−43.9704*	−44.6077*

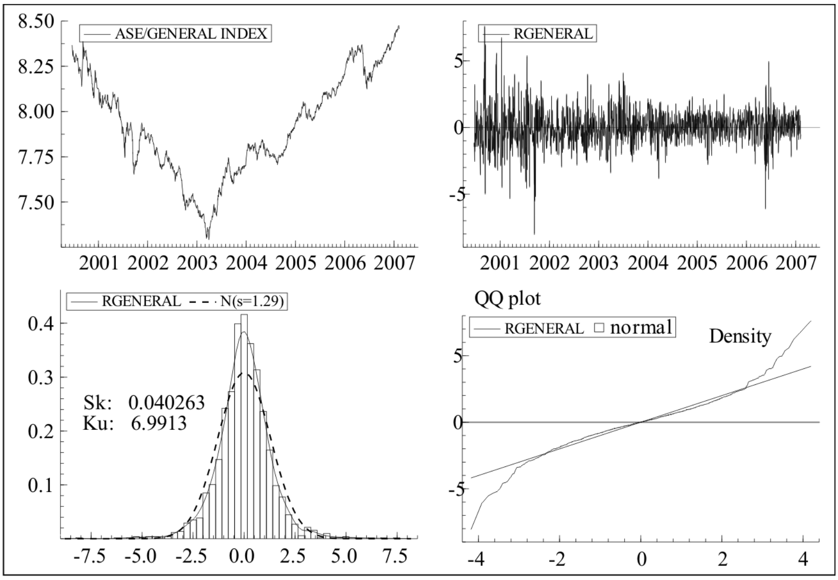
Notes: $R_t = 100 * (\log P_t - \log P_{t-1})$; *D*-statistic is the Kolmogorov-Smyrnov statistic for the null of normality; *B-J* is the Jarque Bera- test for the null hypothesis of normality; $Q(20)$) and $Q^2(20)$ are the Ljung-Box test statistics for up to 20th-order serial correlation in the R_t series. To construct the *PP* statistic we have allowed for up to fourth autocorrelation and used a Bartlett window to ensure positive definiteness. The critical value at 1% level is −3.43 (MacKinnon, 1991, 1993). An asterisk denotes statistical significance at the 1% critical level. The sample period is 20 June 2000 to 8 February 2007 for a total of 1660 observations.

with a normal distribution. The Jarque-Bera normality test statistic as well as the Kolmogorov *D*-statistic is far beyond the critical value which suggests that R_t, is far from a normal distribution. Rejection of normality can be partially attributed to intertemporal dependencies in the moments of the series. Although the accuracy of these statistics, which are based on the null hypothesis that the returns are independently and identically distributed, is often questioned these preliminary findings give support for the non-normality of returns commonly detected in stock price index data. This is the first salient feature of our preliminary diagnostics. Table 1 also presents the Ljung-Box (1978) portmanteau test statistics Q and Q^2 (for the squared data) to test for first- and second-moment dependencies in the distribution of the general index series. The Q statistic indicates that percentage monthly returns are serial correlated. The Q^2 statistic is significant, providing evidence of strong second-moment dependencies (conditional heteroskedasticity) in the distribution of the general index series. However, such tests tend to be biased against the null of serial independence in the presence of conditional heteroskedasticity.

Figure 1 plots the graphs of the log daily stock index together with returns over the sample period.[6] It appears from the graph (Panel b) for the daily returns of the ASE, the phenomenon of volatility clustering discovered by Mandelbrot (1963) is visible: periods of low volatility mingle with periods of high volatility. This indicates that large index returns (both positive and negative) seem to occur in clusters and so does volatility. This is a clear sign of presence of ARCH effect in series indicating that modeling attempts have to take into account heteroskedasticity issues. Panel c also shows that the unconditional distribution of the index returns (full line) is not normal. It is more peaked than the normal density (dashed line) and it has fater tails (this visual indication is validated by the computation of the kurtosis, which is equal to 6.9913). While not obvious on a visual basis, the skewness parameter equal to 0.0403, indicates a positive skewed behavior (see Table 1). A positive value of skewness indicates that for the ASE stock index returns over the sample period considered, the right tail of the distribution is fatter than the left tail, or large positive returns tend to occur more often than large negative returns. Results in Table 1 also show that the mean returns of the index are close to

[6] The graphs are produced with the Ox software using some of its basic commands and default options.

Figure 1: Plots of the logarithm of ASE's general price index, its daily returns, Unconditional Density Estimation and Quintile plot against the Normal



zero, and thus we cannot reject the null hypothesis that the mean returns at 5% level are zero. Additionally we used the Brock Dechert Scheinkman (BDS) and Kočenda(2001, 2005) test statistics (for a detailed description see Brock et al. (1991) and Kočenda,2001, Kočenda and Briatka, 2005). The results of applying the BDS test to the ASE stock index daily price change series are presented in Tables 2 and 3. The calculated test statistics are quite high, indicating that the null hypothesis of independently and identically distributed changes is rejected at the conventional

Table 2: BDS tests on R_T daily price change series (Brock et al. 1991)

ε	$M = 2$		$M = 3$		$M = 4$	
	Asympt	Boot	Asympt	Boot	Asympt	Boot
0.5	0.000	0.000	0.000	0.000	0.000	0.000
1.0	0.000	0.002	0.000	0.000	0.000	0.000
2.0	0.000	0.000	0.000	0.000	0.000	0.000

Notes: Only *P*-values of BDS test statistic are reported.

Table 3: BDS tests on R_T daily price change series (Kočenda, 2001)

β_2	β_3	β_4	β_5	β_6	β_7	β_8	β_9	β_{10}
1.377	2.026	2.645	3.255	3.856	4.452	5.014	5.572	6.151

Notes: All the computed test statistics from the Kočenda (2001) framework using the optimal range of (0.60 σ. 1.90 σ) and a bootstrap sample of 2500 independently drawn from the empirical distribution of the linear model, were rejected at the 1% significance level. The beta coefficients indicate the dimensions. These computations were done using K2K software. The novelty of Kočenda (2001) and Kočenda and Briatka (2005) rests on an alternative way of selecting the range through integration across correlation integral, thereby avoiding arbitrary selection of epsilon, which has long been a weakness of Brock et all (1996) approach.

significance levels. This finding suggests there is some further unexplained structure in the data.

The BDS statistic is given by

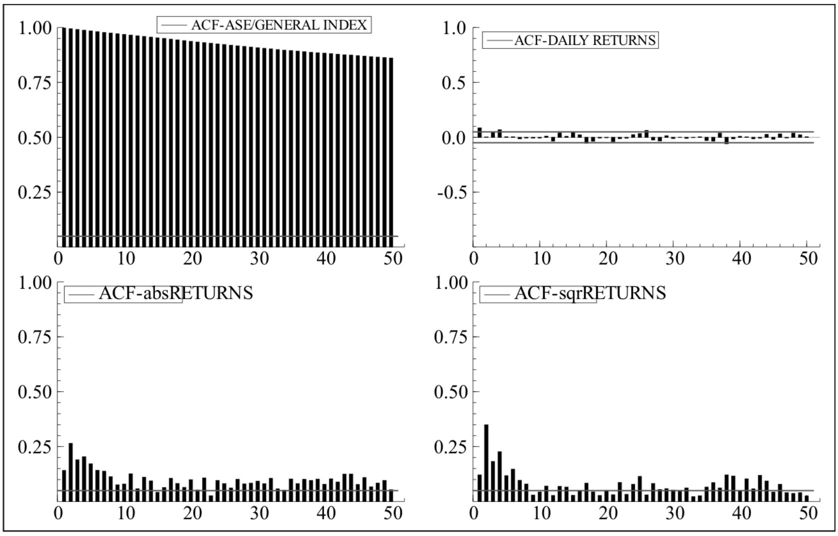
$$\beta_m = \frac{\sum_{\varepsilon} (\ln(\varepsilon) - \overline{\ln(e)}) * (\ln(C_{m,T(\varepsilon)}) - \overline{\ln(C_{m,T(\varepsilon)}})}{\sum_{\varepsilon} (\ln(\varepsilon) - \overline{\ln(\varepsilon)})^2},$$

where β_m is the slope coefficient, calculated from the least squares regression $\ln(C_{m,T(\varepsilon)}) = \alpha_m + \beta_m \ln(\varepsilon_i) + u_i, i = 1, ..., n$, where $\ln(\varepsilon)$ is the logarithm of the proximity parameter, $\ln(C_{m,T(\varepsilon)})$ is the logarithm of the same corelation integral, m is the embedding dimension while bars on variables denote the mean of their counterparts without bars. See Kočenda (2001) and Kočenda and Briatka (2005) for further discussion.

We can see from Figure 1 that the series' variance is not constant over time indicating that modelling attempts have to take into account heteroscedasticity issues. The density graphs and the QQ-plot against the normal distribution in Figure 1 show that returns distributions also exhibit fat tails. To summarize, the daily returns of stock market have the following characteristics: the tail is thick and the distribution is not normal. The return series are a white noise themselves but they are not independent. These findings are consistent with other financial time series.

To gain some insight on dependence structure of the series, Fig. 2 displays the first 50 autocorrelations for the daily log stock index, index returns, absolute returns and squared returns together with two-sided 5% critical values ($\pm 1.96\sqrt{T} = 0.048$), where T is the sample size. The asymptotic critical values are not strictly valid for a process with ARCH effects. Still

Figure 2: Autocorrelation functions of ASE's General price index, daily returns, absolute and squared returns



they may be considered to be useful as guidelines. That the sample autocorrelation of the absolute return decays very slowly demonstrates that the daily return series has long memory property. Even though the ASE stock price index daily returns are uncorrelated over time, the plot in Figure 2 indicates that there are volatile and tranquil periods in returns.

Given the presence of volatility clustering in the return series, any GARCH-type model should be able to capture the volatility dependencies. However, where the sum of the two symmetric GARCH (1,1) parameters approaches one, which is normally the case for high frequency financial asset returns, the simple GARCH (1,1) model reduces to an IGARCH model. In a IGARCH model, fixed sampling interval, e.g., day, is used.

However, to capture long-run dependencies in conditional variance, a dynamically small sampling interval might provide a better approximation of true volatility. Hence, the present study uses the FIGARCH model of Baillie et al., (1996) to model the conditional volatility in ASE general price index returns. It may be noted that one should first test for the presence of long memory in the time series before using the FIGARCH model. The ACF (autocorrelation function) plot of absolute return (Figure 2 Panel 3) shows signs of long memory property in ASE stock price index returns. But there are various statistical tests available to determine the existence of long memory in a time series (Hurst, 1951; Mandelbrot, 1975; Geweke and Porter-Hudak, 1983). This paper uses the GPH test (see Sadique and Silvapulle, 2001 for details on GPH tests).

4.2 Empirical results and Analysis

This section presents the estimation results and the validity, post-estimation tests, of the estimated models. The estimation of the spectral regression has been conducted using different frequencies of periodogram estimates to evaluate the sensitivity of the results to the choice of the sample size. The results in Table 4 provide estimates of the long memory parameter using the GPH tests on absolute return and squared return series. These tests are conducted on the entire sample and the test statistics provide the following observations:

a) The fractional differencing parameter value experienced minimal changes in value ranging from 0.156 to 0.376 with varying the frequency of periodogram ordinates (m) thus, d-value is insensitive to changes in the frequency of the ordinates.
b) There is evidence that the ASE stock index daily returns exhibit fractional dynamics with long-memory features. The statistical significance of estimated d has been tested twice. The first hypothesis is a two-tailed t-statistic testing for $H_0: d = 0$ versus $H_1: d \neq 0$, and the second is one-tailed t-statistic testing for $H_0: d = 0$ versus

Table 4: Long Memory Tests

Ordinates (m)	R_t^2	$\|R_t\|$
$T^{0.5}$	0.234 (2.046)*	0.376 (3.291)*
$T^{0.6}$	0.156 (2.084)*	0.265 (3.553)*
$T^{0.7}$	0.342 (6.873)*	0.296 (5.944)*
$T^{0.8}$	0.350 (9.911)*	0.264 (7.470)*

Notes: m stands for the number of periodogram ordinates used in the GPH estimator.

$H_1: d > 0$. The null hypothesis in both tests has been rejected in favour of *d*-value is statistically significantly greater than zero. Therefore the process is the process is said to be stationary which is in line with rejection of the unit root tests and exhibits long-memory process.

c) The process is considered to be long-range positive dependence as de (0, 0.5) and $d \neq 0$. Consequently, the process is not mean reverting and cannot be presented using ARMA models.

This result supports the Taylor effect (see Taylor, 1986, pp. 52-55) as in general estimate of the long memory parameter is higher for the absolute returns than that of the squared returns.

Having identified long memory property in ASE stock index absolute and squared return series, this paper has attempted to model volatility of index returns using the FIGARCH model. Ordinary GARCH model has also been used ignoring the long memory property. To apply the above models, one requires deciding first on a suitable mean equation and then a suitable volatility equation. Since the index return series does not exhibit long memory property (Figure 2) we have not tried fractionally integrated mean equations for modelling the return series. Different specifications for the conditional mean of returns and conditional variance are used. A random walk mean model without drift shows that the return series is non-normal. We have used also a random walk model with drift and found that the constant term is significantly different from zero. An AR (1) model found to describe the conditional mean of the returns better than a Martingale process. This indicates that there is some predictability in the conditional mean, a result contrary to evidence on developed stock markets.

After modelling the mean of the ASE stock index return series, its conditional volatility is modelled using various competing GARCH models as described in the previous sections. The selection procedure is based on each model's ability to produce forecasts, the significance of ARCH (Alpha) and GARCH (Beta) parameters, the Log-Likelihood (highest value is preferred) and the Akaike information criteria (AIC) which is used as a model selection guide and to determine the appropriate length of the distributed lag by choosing the specification with the lowest value of the AIC.

The estimation results indicate that the appropriate specification for the standard symmetric GARCH $(p,\ q)$-model is $p = 1$; $q = 1$ and Table 5 shows the parameter estimates for the chosen AR (1) - GARCH (1,1) model.

Regarding the estimated parameters of the AR (1) - GARCH (1,1) model, as presented in Table 5 (see also Figure 3), the coefficients of ARCH (Alpha1) and GARCH (Beta1) in the conditional variance equation are highly significant providing evidence that the conditional volatility is time variant and there is volatility clustering. Also, as is typical of GARCH model estimates for financial asset returns data, the sum of the coefficients on the lagged squared error and lagged conditional variance is close to unity this implies that shocks to the conditional variance will be highly persistent indicating that large changes in returns tend to be followed by large changes and small changes tend to be followed by small changes, which means that volatility clustering is observed in the Greek financial returns series.

Table 5: Estimated Parameters for the Chosen model AR(1) - GARCH (1,1) With Gauss Distribution for the Greek Stock Market Index Returns.

Parameters	Coefficient	Std-.Error	*t*-value	*t*-prob
Cst(M)	0.0671	0.02828	2.374	0.0177
AR(1)	0.1002	0.0255	3.744	0.0002
Cst(V)	0.0226	0.0170	1.333	0.1828
ARCH(Alpha1)	0.0836	0.0290	2.879	0.0040
GARCH(Beta1)	0.9039	0.0368	24.550	0.0000
Akaike info criterion	3.1389			
Log likelihood	−2598.69			

Notes: The reported coefficients shown in the table are Quasi Maximum Likelihood Estimates of Bollerslev and Wooldridge (1992) (*p*-values in parenthesis) for the AR (1)-GARCH (1,1) Model

In fact, the GARCH (Beta1) coefficient is relatively high and ARCH (Alpha1) coefficient low, indicating that volatility does 'persist' for long. However, the AR (1) - GARCH (1,1) model fails the normality test implying thereby that the error distribution is not normal. Other tests are performed to see if the autocorrelation in the squared return has successfully been removed (Ljung-Box-Pierce Q-test) and to see whether or not the conditional heteroskedasticity that existed in the return time series have successfully removed (Engle's ARCH-test). Finally the Jarque-Bera test is used to test the null hypothesis of whether the standardized residuals are normally distributed. All these tests and measures are presented in Table 6.

Without going too deeply into the analysis of these results, we can briefly argue that the model does not capture the dynamics of the ASE stock price index. The Q-statistics on standardized and squared standardized residuals, and the Residual-Based Diagnostic (RBD) for conditional hete-

Table 6: Validity tests of the AR(1) - GARCH(1,1) with Gauss Distribution for the Greek Stock Market Index Returns.

The Test	*Statistic*	*P-Value*
Ljung-Box-Pierce Q-test	$Q(10) = 9.18371$	(0.0000)
	$Q(20) = 20.3137$	(0.0000)
	$Q(50) = 41.5533$	(0.0000)
	$Q^2(10) = 31.4938$	(0.0000)
	$Q^2(20) = 46.3128$	(0.0000)
	$Q^2(50) = 87.9929$	(0.0000)
Engle's ARCH-test		
ARCH 1-2 test	F(2,1652) = 9.4756	(0.0001)
ARCH 1-5 test	F(5,1646) = 5.3770	(0.0001)
ARCH 1-10 test	F(10,1636) = 3.3214	(0.0003)
Skewness	−0.09796	(0.10302)
Excess Kurtosis	1.1227	(8.866e-021)
Jarque- Bera test	89.786	(3.18540e- 020)
Adjusted Pearson Chi-square	Cell 40 = 61.000	(0.0030)
Goodness-of-fit test	Cell 50 = 69.661	(0.0082
	Cell 60 = 76.081	(0.0255)
Residual-based	RBD(2) = 17.109	(0.0001)
Diagnostic for Conditional	RBD(5) = 20.212	(0.0011)
Heteroskedasticity (Tse,2002)	RBD(10) = 32.141	(0.0003)

roskedasticity (Tse, 2002)[7] with various lag values as well as the adjusted Pearsob Chi-Square goodness −of-fit test (with different cell numbers)[8] reject the null hypothesis of a correct specification.

---

7 The Box Pierce portmanteau statistic is perhaps the most widely used diagnostic for conditional heteroscedasticity models.
Although it has been used that the portmanteau statistics do not have an asymptotic x^2 distribution, many authors, nonetheless, apply the x^2 distribution as an approximation (the problem lies in the fact that estimated residuals are used to calculate the portmanteau statistics). To overcome the problem, TSE (2002) proposed a Residual − Based Diagnostic for conditional heteroscedasticity. The diagnostic involves running artificial regressions and testing for the statistical significance of the regression parameters. The Key problem is that since the regressors are estimated, the usual ordinary least squares (OLS) result does not apply. The idea of the Residual − Based Diagnostic test for conditional heteroscedasticity is the following: after estimating the model, the standardized residuals $\hat{z}_t = \hat{\varepsilon}_t / \hat{\sigma}_t$ can be computed. It is obvious that $\hat{z}_t$ depends on the set of estimated parameters. $E(\hat{z}_t^2) = 1$ by construction, so we can run a regression of $E(\hat{z}_t^2) - 1$ on some information variables and examine the statistical significance of the regression parameters. Tse (202) proposes to run the following OLS regression to test the presence of the remaining heteroscedasticity in the standardized residuals: $E(\hat{z}_t^2) - 1 = d_1 \hat{z}_{t-1}^2 + ... + d_M \hat{z}2_{t-M} + u_t$. Since the regressors are not observed (but estimated), standard inference procedures of OLS is invalid. Tse (2002) derives the asymptotic distribution of the estimated parameters and shows that joint test of significance of the $d_1, \ldots, d_M$ is now $x^2(M)$ distributed.

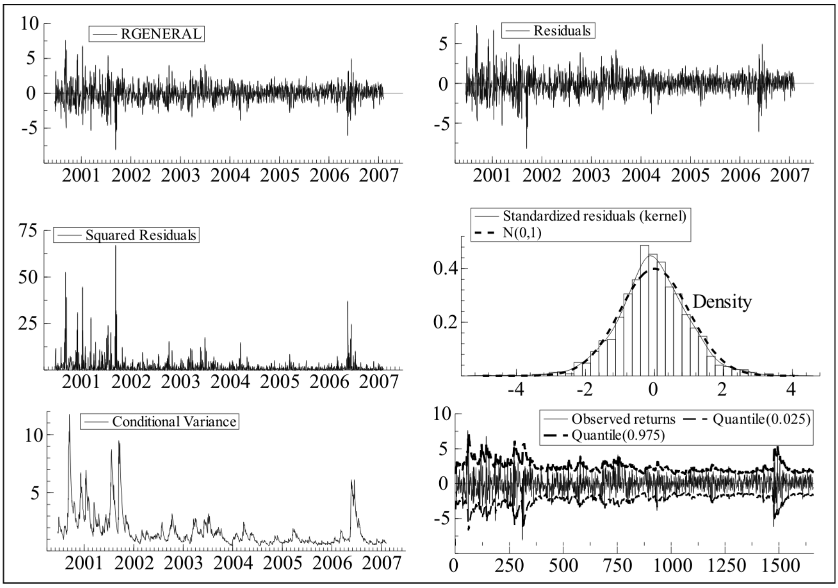
8 The Pearson goodness-of-fit test compares the empirical distribution of the innovations with the theoretical one. In order to carry out this testing procedure, it is necessary to first classify the residuals in cells according to their magnitude. (See Palm and Vlaar, 1997, for more details) For a given number of cells denoted g, the Pearson goodness-of-fit statistic is:

$$P(g) = \sum_{i=1}^{g} \frac{(n_i - En_i)^2}{En_i}$$

where n_i is the number of observations in cell i and En_i is the expected number of observations (based on the ML estimates). For *i.i.d.* observations, Palm and Vlaar, 1997, show that under the null of a correct distribution the asymptotic distribution of $P(g)$ is bounded between a

Also results presented in Table 6 show that the standardized residuals are leptokurtic and the Jarque-Bera statistic strongly rejects the hypothesis of normal distribution, which means that the fat-tailed asymmetric densities outperform the gaussian for modeling and forecasting the Egyptian stock market index returns.

Figure 3: AR(1) - GARCH(1,1) model for daily returns on ASE General price index



Briefly, looking at the overall results, we can argue that the AR(1) - GARCH (1,1) model does not perform well with the dataset we have investigated.

The positive skewness in the return series (Table 1) indicates the absence of leverage effect in ASE stock index volatility and hence an asymmetric

---

$x^2(g-1)$ and a $x^2(g-k-1)$ where k is the number of estimated parameters. As explained by Palm and Vlaar, 1997, the choice of g is far for being obvious. For $T = 2252$ these authors set g equal to 50. According to König and Gaab, (1982), the number of cells must increase at a rate equal to $T^{0.4}$

GARCH model would be inferior to a symmetric GARCH model. The high persistence of volatility in the AR(1) - GARCH(1,1) model suggests that the model may be non-stationary. To allow for high persistence of volatility while avoiding complications of the IGARCH model, we use FIGARCH models.

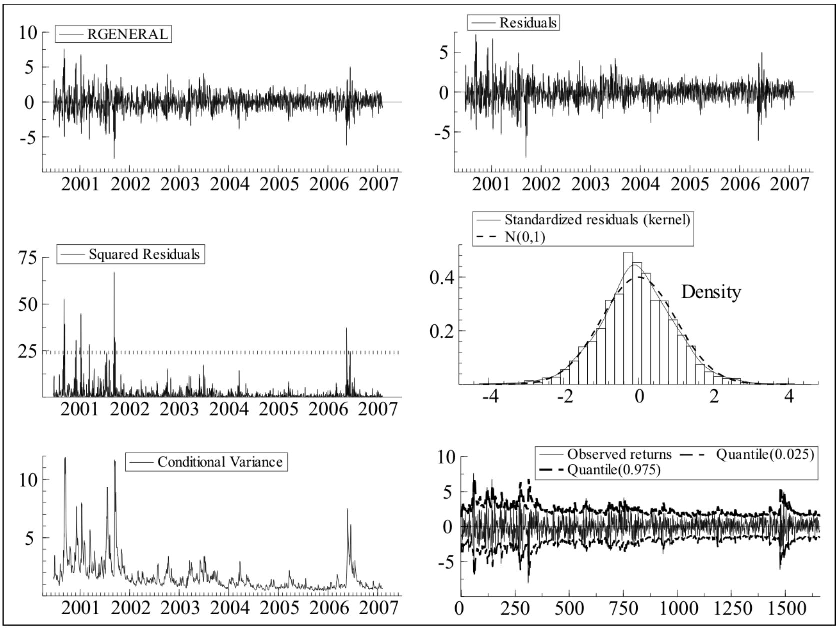
Table 7 (see also Figure 4) shows the estimates of AR (1)-FIGARCH $(1, d, 0)$ model parameters. The fractional difference parameter d under the AR(1) - FIGARCH(1, d, 0) model is less than 0.5, indicating that the ASE stock index returns exhibit fractional dynamics with long memory features. In comparing the GARCH model against the FIGARCH alternative, as can be seen from the table, in terms of diagnostics statistics, AR(l) - FIGARCH(1, d, 0) performs better than AR(1) - GARCH (1, 1) model. For instance the AIC information criterion, selects the FIGARCH specification. The standardized residuals from the estimated models exhibit less skewness and kurtosis than the returns. The Q-statistics on the standardized and squared residuals and the RBD test with various lag values also indicate that a FIGARCH specification does a better job in terms of taking care of persistence in the conditional volatility. This conclusion is reinforced by the Pearson Chi-Squared goodness-of-fit test: the model specifica-

Table 7: Estimated Parameters for the Chosen model AR(1) - FIGARCH (1, d, 0) with Normal Distribution for the Greek Stock Market Index Returns

Parameters	*Coefficient*	*Std.-Error*	*t-value*	*t-prob*
Cst(M)	0.0684	0.0274	2.501	0.0125
AR(1)	0.0996	0.0254	3.817	0.0001
Cst(V)	0.0673	0.0259	2.599	0.0094
GARCH(Beta1)	0.3192	0.0665	4.803	0.0000
d-FIGARCH	0.3669	0.0632	5.821	0.0000
Akaike info criterion	3.1190			
Log likelihood	–2582.174			

The reported coefficients shown in the table are Quasi Maximum Likelihood Estimates of Bollerslev and Wooldridge (1992) (p-values in parenthesis) for the AR(1) - FIGARCH(1,1) Model.

Figure 4: AR(1) - FIGARCH(1, *d*, 0) model for daily returns on ASE stock price index



tion is not rejected by the goodness-of-fit tests for various lag lengths. Note also that the sum of the estimates of α a and β in the GARCH(1,1) model is close to one, indicating that the volatility process is highly persistent, and a FIGARCH model may better model the persistence in the conditional volatility.

The results from FIGARCH(*l*, *d*, 0) indicate that conditional variance of ASE stock index returns contain long memory. The estimate of 'long memory parameter', *d*, for daily data is 0.421. This estimate is significantly different from zero. In a FIGARCH model, the long memory parameter corresponds to the squared error term. Hence, results from Table 2 provide evidence that the squared stock returns exhibit long memory. The results are in line with the estimates of long memory parameter for GPH reported in Table 4.

Table 8: Validity Tests of the AR(1) - FIGARCH(1, *d*, 0) Model with Normal Distribution for heGreek Stock Market Index Returns

The Test	*Statistic*	*P-Value*
Ljung-Box-Pierce *Q*-test	$Q(10) = 6.8211$	(0.6557)
	$Q(20) = 18.3079$	(0.5020)
	$Q(50) = 41.8615$	(0.7553)
	$Q^2(10) = 9.0815$	(0.4298)
	$Q^2(20) = 19.0454$	0.4539)
	$Q^2(50) = 57.0662$	(0.2003)
Engle's ARCH-test		
ARCH 1-2 test	F(2,1653) = 1.7833	(0.1684)
ARCH 1-5 test	F(5,1647) = 1.1119	(0.3519)
ARCH 1-10 test	F(10,1637) = 0.9667	(0.4706)
Skewness	−0.037165	(6. 4851e-012)
Excess Kurtosis	0.8033	(2.2480e-011)
Jarque- Bera test	44.989	(1.7008e- 010)
Adjusted Pearson	Cell 40 = 56.66	(0.8335)
Chi-square	Cell 50 = 69.66	(0.4303)
Goodness-of-fit test	Cell 60 = 84.55	(0.3163)
Residual-based	RBD(2) = 3.073	(0.2151)
Diagnostic for Conditional	RBD(5) = 3.681	(0.5962)
Heteroskedasticity (Tse, 2002)	RBD(10) = 9.634	(0.4731)

5. Concluding Remarks

Stock prices volatility has received a grate attention from both academics and practitioners over the last two decades because it can be used as a measure of risk in financial markets. Recent portfolio selection, asset pricing, value at risk, option pricing and hedging strategies, highlight the importance of modeling the conditional volatility of returns.

This paper has investigated the issue of volatility clustering and long memory in Greek stock market. The research had been approached empirically by testing the presence of fractional dynamics, i.e. long memory in ASE's returns, using two methodologies: a semi-parametric method due to Geweke and Porter-Hudak (GPH) and a fractional integrated GARCH(FIGARCH) model. The investigation is conducted using ASE's General composite stock price index daily returns, during the period 20 June 2000 till 8 February 2007.

The long memory AR(1) - FIGARCH(1, *d*, 0) model is found to provide a good representation of the daily returns. Estimates of the long memory parameter, *d*, are found to be significantly different from 0, suggesting that ASE's stock price index volatility is a long range dependence process, thus rejecting a GARCH specification. The above results are consistent with the evidence provided by Barkoulas et al., (1997).

Thus the hypothesis that the Greek stock market is weakly efficient is rejected due to long range dependence in daily returns. The evidence is consistent with number of emerging market characteristics. Further more, analysis of squared and absolute returns supports the long memory in volatility process. In particular, auto-correlations of squared and absolute returns and estimates from GPH supported the findings from the FIGARCH model.

Moreover, results from estimates of long memory parameter provide evidence of the so called Taylor effect. The evidence on the presence of long memory in absolute and squared returns is similar to that obtained from major capital market in the literature.

The finding of short memory in returns is contrary to the evidence of long memory in the conditional mean of return process for some other emerging capital markets. The evidence of long memory component presented in this study may indicate that financial security prices are not immune to persistent informational asymmetries especially over longer time periods.

References

Baillie, R., and T. Bollerslev, 1989, The Message in Daily Exchange Rates: A Conditional-Variance Tale, Journal of Business and Economic Statistics, 7, 297-305.

Baillie, R., T. Bollerslev, and H. Mikkelsen, 1996, Fractionally Integrated Generalized Autoregressive Conditional Heteroskedasticity, Journal of Econometrics, 74, 3-30.

Baillie, Richard T., 1996, Long Memory Processes and Fractional Integration in Econometrics, *Journal of Econometrics* 73(1), pp. 5-59.

Bollerslev, T., 1986, Generalized Autoregressive Conditional Heteroskedasticity, Journal of Econometrics, 31, 307-327.

Bollerslev, T., Diebold, F. X. and Labys, P. (2001), The distribution of realized exchange rate volatility, Journal of the American Statistical Association 96 (453) 42-55.

Bollerslev, T., and H. O. Mikkelsen, 1996, Modeling and Pricing Long-Memory in Stock Market Volatility, Journal of Econometrics, 73, 151-184.

Bollerslev, Tim, R.F. Engle and D. B. Nelson, 1994, ARCH Models, in Chapter 49 of Handbook of Econometrics, Volume 4, North-Holland.

Bollerslev, T., Chou, R.Y. and Kroner, K.F. (1992), ARCH modeling in finance: a review of the theory and empirical evidence, Journal of Econometrics, 52, 5-59.

Bollerslev, T. (1987), A Conditionally Heteroskedastic Time Series Model for Speculative Prices and Rates of Return, *Review of Economics and Statistics,* 69, 542-547.

Bollerslev, T., and J. Wooldridge (1992), Quasi-maximum likelihood estimation inference in dynamic models with time-varying covariances, *Econometric Theory,* 11, 143-172.

Brailsford, T., and R. Faff (1996), An evaluation of volatility forecasting techniques, Journal of Banking and Finance, 20, 419-438.

Brooks, C., Burke, S. P. & Persand, G. (1997), Linear and non-linear (non)-forecastability of highfreqency exchange rates, Journal of Forecasting 16, 125-145.

Brooks, C., Burke, S. P. & Persand, G. (2001), Benchmarks and the accuracy of garch model estimation, International Journal of Forecasting 17, 45-56.

Bernanke, B, and M. Gertler, 1999, Monetary policy and asset price volatility, in New Challenges for Monetary Policy: A Symposium Sponsored by the Federal Reserve Bank of Kansas City, Federal Reserve Bank of Kansas City, 77-128.

Cheung, Y. W., K.S. Lai, and M. Lai, 1993, Are there long cycles in foreign stock returns? Journal of International Financial Markets, Institutions and Money 3, 33-47.

Chou, W. L. and Shih, Y.C., 1997, Long-run purchasing power parity and long-term memory: evidence from Asian newly industrialized countries, Applied Economics Letters 4, 575-578.

Day, T., and C. Lewis (1992), Stock Market Volatility and the Information Content of Stock Index Options, Journal of Econometrics, 52, 267-287.

Ding, Z., C. W. J. Granger, and R. F. Engle (1993), A Long Memory Property of Stock Market Returns and a New Model, Journal of Empirical Finance, 1, 83-106.

Engle, R., and T. Bollerslev, 1986, Modeling the Persistence of Conditional Variances, Econometric Reviews, 5, 1-50.

Engle, R., and V. Ng, 1993, Measuring and Testing the Impact of News on Volatility, Journal of Finance, 48, 1749-1778.

Engle, R. (1982), Autoregressive conditional heteroscedasticity with estimates of the variance of United Kingdom inflation, *Econometrica,* 50, 987-1007.

Engle, R., and T. Bollerslev (1986), Modeling the Persistence of Conditional Variances, Econometric Reviews, 5, 1-50.

Engle, R., and G. Gonzalez-Rivera (1991), Semiparametric ARCH Model, Journal of Business and Economic Statistics, 9, 345-360.

Fang, H., Lai, K. S., and Lai, M., 1994, Fractal structure in currency futures price dynamics, The Journal of Futures Markets 14, 169-181.

Fama, E. (1965), The Behavior of Stock Market Prices, *Journal of Business,* 38, 34-105.

Geweke, J., 1986, Modeling the Persistece of Conditional Variances: A Comment, Econometric Review, 5, 57-61.

Geweke, J. and S. Porter-Hudak, 1983, The Estimation and application of long memory time series models, Journal of Time Series Analysis 4, 221-237.

Greene, T.M., and D.B. Fielitz, 1977, Long-term dependence in common stock returns, Journal of Financial Economics 4, 339-349.

Glosten, L., R. Jagannathan, and D. Runkle (1993), On the relation between expected return on stocks, *Journal of Finance,* 48, 1779-1801.

Geweke, J. and Porter-Hudak, S. (1983), The estimation and application of long memory time series models, Journal of Time series Analysis, 1, 15-29.

Gokcan, S. (2000), Forecasting volatility of emerging stock markets: linear versus Nonlinear GARCH models, Journal of Forecasting 19, 499-504.

Hamilton, J. D. (1994), *Time Series Analysis,* 4 ed, Princeton University press. Hansen, B. E. (1994)

Helms, B. P., Kaen, F. R., and Roseman, R. R., 1984, Memory in commodity futures contracts, The Journal of Futures Markets 4, 559-567.

Hurst, H.E., 1951, Long-term storage capacity of reservoirs, Transactions of the American Society of Civil Engineers 116, 770-799.

Jarque, C., and A. Bera (1987), A Test for Normality of Observations and Regression Residuals, International Statistical Review, 55, 163-172.

Jacobsen, B., 1996, Long term dependence in stock returns, Journal of Empirical Finance 33, 393-417.

Klaasen, F. (2002), Improving GARCH volatility forecasts with regime switching GARCH, Empirical Economics 27, 363-394. *Econometric Review,* 5, 71-74.

Kao, G. and Ma, C., 1992, Memories, heteroskedasticity, and price limit in currency futures markets, Journal of Futures Markets 12, 679-692.

Kilic, R. (2004), On the long memory properties of emerging capital markets: evidence from Istanbul stock exchange, Applied Financial Economics, 14, 915-922

König, H., and W. Gaab, (1982), The Advanced Theory of Statistics, vol. 2 of Inference and Relationships. Haffner. New York.

Lobato, I.N. and Savin, N.E. (1998), Real and spurious long-memory properties of stock-market data, Journal of Business & Economic Statistics, 16, 261-83.

MacKinnon, J.G., 1991, Critical Values for Cointegration Tests, Chapter 13 in Long-run Economic Relationships: Readings in Cointegration, edited by R.F.Engle and C.W.J. Granger, Oxford University Press.

Mandelbrot, B., 1963, The Variation of Certain Speculative Prices, Journal of Business, 36, 394-119.

Nawrocki, D., 1995, R/S analysis and long term dependence in stock market indices, Managerial Finance 21(7), 78-91.

Nelson, D.B. (1991), Conditional heteroskedasticity in asset returns: A new approach Econometrica 53, 347-370.

Palm, F. and Vlaar, P. (1997), Simple Diagnostics Procedures for Modelling Financial Time Series. *Allgemeines Statistisches Archiv,* 81, 85-101.

Taylor, Stephen, 1986, *Modelling Financial Time Series,* New York: John Wiley & Sons Ltd.

Tse, Y.K. (2002), Residual-based Diagnostics for Conditional Heteroskedasticity Models, Econometrics Journal, 5, 358-373.

AN ECONOMETRIC ANALYSIS OF SECTORAL DEMAND FOR ELECTRICITY IN GREECE AT REGIONAL LEVEL: SOME USEFUL OBSERVATIONS

Dr. Paraskevi V. Boufounou*

Abstract

The price elasticity of demand for electricity is a convenient way for summarizing how changes in the market price or quantity consumed affect each other, since it is the ratio of two percentages; the change in quantity consumed that results from a change in price. A reliable measure of this relationship could be valuable to the wide variety of financial instruments requiring pricing decisions. The present article focuses on estimating price elasticities of demand for electricity at a disaggregated level, both in terms of 19 different consuming sectors and 5 geographical regions, for Greece pooling together cross-sectoral and time-series data on both yearly and monthly basis. An econometric model that allows for the demand of the previous period, the price of electricity, the income and the temperature characteristics to be considered is estimated and the resulting estimates are evaluated. One of the more striking results of this endeavor is that it became apparent that there are substantial differences in behavior in different regions of the country, which must be taken into account in any interpretation of the demand side.

The article is organized as follows:

- First with some important issues relevant to the electricity supply industry are presented.

* Assistant Professor, TEI of Ionian Islands

- Then the model is introduced, its actual formulation is presented, and a complete specification in terms of spatial, temporal, sectoral and econometric settings is attempted, together with a detailed presentation of the data obtained, constructed, and used in the present study, along with all the limitations, constraints and assumptions implied.
- Finally, the results obtained are presented and subjected to comment in the light of those expected from previous studies.

Keywords: Electricity demand, Econometric analysis, pricing
JEL Classification: D4

1. Characteristics of the Electric Supply Industry

1.1 Pricing Structure Determination

The electrical industry is regulated in such a way[1] that the public will be able to receive all the efficiency benefits, and at the same time to avoid all the undesirable tendencies of monopolies to limit output and charge prices higher than the competitive norm.[2] [Kahn 70] also states that natural monopolies should, if feasible, be regulated so as to produce the same result as if there was effective competition instead. Hence, the common economic belief is that in a regulated market, maximum social welfare can be achieved when every producing unit produces up to the point[3] *at which the cost of the last unit produced equals the price the consumers are willing to pay for this level of production.* (page 6)

It is not surprising then, that the Public Power Corporation of Greece, even though it is a monopolist, does not behave as such by seeking profit maximization. Instead, it seeks a policy of maximizing social welfare in relation to available and future electrical energy supplies.[4]

Setting prices equal to marginal cost[5] in order to maximize social welfare

---

1 For a commenting analysis date back to studies originated by [Henderson 47], [Moore 70].

2 See initial work from [Wilcox 71].

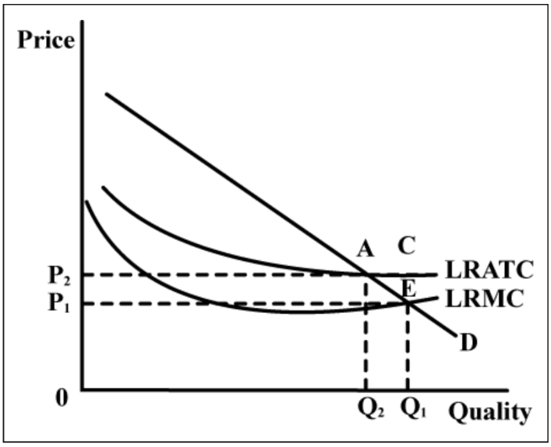
3 See initial work from [Uri 75].

4 For a commenting analysis of PPC's tariff policy see [Delis 87].

5 Arguments in favour of marginal cost pricing for utilities date back to the

in the naturally monopolistic electrical industry causes problems. If the long run average total cost curve LRATC (Fig 1.1) is falling, the long run marginal cost curve LRMC must lie below that. Hence, if the following the pricing rule price is OP_1 the output will be OQ_1, and since average cost $Q_1C = OP_2 > OP_1$, there is a deficit equal to the area P_1P_2CE (Fig 1.1). The possible solutions[6] are three:

Figure 1.1: Marginal cost pricing with falling long-run costs



Firstly, the deficit could be covered by some form of government subsidy out of tax revenues, which would satisfy the proximate allocative criterion, as well. But this "prescription" is associated with certain disadvantages,[7] such as:

- These subsidy programs usually require the detailed authorization of legislators, and therefore can easily degenerate into a "pork barreling process", which is of course undesirable.
- The government in order to subsidize the deficit may increase personal income taxes, which will result in even more subtle allocative distortions, since work will become less attractive at the margin.

article written in 1844 by the French engineer [Dupuit 52]. Important later initial references are: [Boiteux 56], [Hotelling 38], [Ruggles 50].

6 See initial work from [Scherer 70].

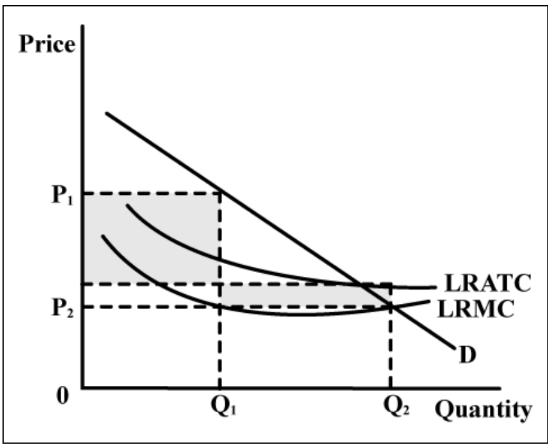
7 [Scherer 70] pioneers a more comprehensive analysis of this subject.

- Since a subsidy represents an income redistribution from the general tax paying public to the narrower electricity consumer class, there may be undesirable distributional consequences.

Hence, this method is usually not used because of either unability or unwillingness.

Secondly, the solution could be the imposition of a rule under which the price, if uniform, is set to equal average total cost OP_2, as at output OQ_2 (Fig. 1.2), or it uses discriminatory price structure (where the average price level equals average total cost), including normal profit. Yet, this is a method not usually used.

Figure 1.2: Discriminatory marginal cost pricing with falling long-run costs



Price discrimination provides a final solution by squeezing out additional revenue from affluent and eager buyers (output OQ_1 sold at price OP_1), while selling on the margin, at a price approximating marginal cost (output OQ_2 sold at price OP_2) (Fig 1.2). So, the gains from the first case (darker shaded area) more than offset the loses from the second (lightly shaded area) (Fig 1.2).[8]

---

[8] Some important initial studies are the following: [Berman and Hammer 73], [Berman, Hammer and Tihansky 72], [Garbacz 82].

This form of block pricing discrimination method is frequently sanctioned in electrical energy regulation.[9] Usually, in the residential sector there is a high charge per unit for the first few KWH that serve the most vital needs (e.g. illumination), and a lower price level for the remainder. In the industrial sector, prices are lower since firms can produce their own power if they believe the prices are too high, or they can move to other regions where electricity is cheaper, etc. Hence, the fact that a price structure is developed, which apparently takes advantage of the differing price elasticities of demand among various consuming sectors, explains the perceived variability of per unit price among them.

1.2 The Peaking Demand Problem

A very important aspect of the demand for electricity is the difference between peak and offpeak demand. The demand pattern changes according to the time of the day, in different consuming sectors, and it gave rise to a whole literature dealing with this issue. Specifically, [Cargill and Meyer 71] introduce the problem, even though their analysis does not incorporate interdependencies in consumption at different times of the day and does not deal with many different consuming sectors. However, [Caves and Christensen 80] do shed some light on the former problem, but their study is limited to the household sector.[10] Another dimension of the peaking demand problem of even greater relevance to public policy, especially for Greece, is the seasonal peaks in demand. The present model does not allow for such implications.

1.3 Demand & Supply in Electrical Energy Industry

As [Uri 75] stated:

> *The electrical energy industry is characterized by a separation of supply and demand locations and by a fixed amount of transmission capacity available at any time*. (page 2)

---

9 See also the following pioneering articles: [Feldstein 72], [Pace 75], [Terza and Welch 82].

10 See also the introductory studies of: [Betancourt 81], [Caves and Christensen 79].

This allows the consideration of the demand side alone in the short run.[11] Hence, the main purpose of this study is to estimate a sufficient set of demand equations (for different consuming sectors and different geographical regions), to estimate their parameters and deduce the relevant elasticities.

Estimating a set of price elasticities of demand[12] for the various consuming sectors is critically important for attempting analysis of electrical energy policy problems,[13] such as:

- Forecasts of the future electricity demand.[14]
- Assessments of electricity tax policies.
- Evaluations of the appropriate timing for new electricity technology development.[15]
- Predictions of future E.U., etc. pricing strategies.[16]

More specifically, the higher the price elasticity of electricity demand[17]:

1. The lower the impact of a given reduction in quantity of available electricity.
2. The lower the forecasted future demand in high price situations.[18] The smaller the price increase required to reduce the Electricity/GNP ratio a given amount.[19]

---

[11] For discussion, see the following: [Koopmans 51], [Takayama and Judge 64a], [Takayama and Judge 64b], [Takayama and Woodland 70], [Samuelson 52], [Samuelson 57].

[12] See [Smith 80].

[13] See the studies of: [Hsiao and Hsiao 85], [Kouris 81].

[14] Some important articles are: [Gill and Tyrrell 74], [Uri 80].

[15] See [Bullard and Sebald 75].

[16] See the following articles: [Smil and Kuz 76], [Starr 78].

[17] See [EMF 4 81].

[18] See [Gill and Tyrrell 74].

[19] The consumption reduction in response to increasing electricity prices or costs depends upon the reduction in aggregate economic activity and the ability of actors in the economy to substitute other inputs for electrical energy. However, the ratio of electrical energy use to GNP depends primarily upon the ability of the economy to substitute capital and labour inputs for

3. The less urgent the perceived need for new electricity supply technology.[20]
4. The smaller the impact on consumption of a given reduction in the cost of imported electricity.

2. The Econometric Model

2.1 Constant Elasticity Demand Model

The neat *Marshallian*[21] analysis of the operation of a market in terms of a demand schedule and a supply schedule naturally invited many attempts to establish their slopes. Demand analysis as an application of linear regression to aggregate economic data was first used by [Moore 14] in the early years of this century, and his work has established a tradition of which some traces persist to the present day.

Naturally, the most convenient way to estimate a demand function is to develop a single form relationship of price and quantity. Unfortunately, an important identification problem emerges[22] in the particular case of electricity, so something like that would not be wise. We have, therefore, to proceed by using a more indirect estimating method.

As previous analyses show[23] a method that depicts reality sufficiently well is that of the "Constant Elasticity Model" of demand. According to that, if e.g. we suppose that goods do have constant income elasticities, then an increase in a consumer's income will be accompanied by an increase in the purchase of goods with high income elasticities, so:

$$\sum_{i=1}^{k} w_i n_i$$

will increase, where:

w_i = budget share of the ith good (which will increase for high elasticity goods)

---

electrical energy, as measured by the aggregate elasticity of demand. For a complete analysis see: [Kraft and Kraft 78], [Zilberfarb and Adams 81].

20 See [Bullard and Sebald 75].

21 See [Marshall 90].

22 The identification problem is fully discussed in [Working 27].

23 See [Uri 75].

n_i = income elasticity of the ith good (which is constant)

But this is not feasible for all k goods, since:

$$\sum_{i=1}^{k} w_i n_i = 1$$

always. Hence, this model does not exactly satisfy the classical demand[24] theory, as [Bridge 67] states. Despite its disadvantages (including that of "nonadditivity")[25] it is widely used because of its ease of estimation. Specifically, [Houthakker 65] states:

> *It is without serious rivals in respect of goodness of fit, ease of estimation and immediacy of interpretation.* (page 278)

This is why it has been chosen for this study. However, it should be pointed out that the above claim has been seriously questioned by the proposition of the "Linear Expenditure System" of [Goldberg and Gamaletsos 67] and by the "Rotterdam School Model" developed by [Barten 64], where there is also a pragmatic function with the classical constraints only approximately satisfied.

Hence, the final choice has been made after comparing results of these studies in the light of the topics considered. Specifically, [Houthakker 65] is concerned with the estimation of a demand function for household expenditure, but the results obtained concerning the price elasticities from the "within" and "between" country regression analyses (where the former are regarded as short run elasticities and the latter as long run elasticities), are still applicable in our functional form, even if it is different. [Goldberg and Gamaletsos 67] indicate that the price coefficients estimated by [Houthakker 65], can be interpreted as neither Slutsky "compensated" nor "uncompensated" price elasticities, because of the general price deflator for both income and price terms. They furthermore state that the better fit Houthakker found for the average budget shares

---

24 See [Goldberg 67].

25 Additive variants of double log functions are investigated in the following articles: [Houthakker 60a] (He shows that the price effect can be separated into an income effect, a specific substitution effect and a general substitution effect, and so enables the estimation of demand functions' slopes after compensating for the income effect), [Houthakker 60b], [Lester 63].

than their results (using their "L.E.S."), is at the expense of Houthakker's introduction of more parameters and of his abandonment of a tight theoretical framework. Finally, they remark that the parameters vary between countries, and that a model which predicts expenditure may not predict average price shares accurately (and of course the prediction of the latter is very important if changes in consumption composition are of interest). We have tried in this study to circumvent these specific problems, whilst using Houthakker's framework.

In our case, we use the "Variable Elasticity Model", which is a generalization of the "Constant Elasticity Model", implying that each elasticity varies as the level of the corresponding factor varies.

2.2 Variable Elasticity Model Specification

The Constant Elasticity Model of demand analysis can be written as follows:

$$Q_{ijt} = A_{ij} Q_{ij(t-1)}^{b_{ij}} F_{1_{ijt}}^{c_{1_i}} \ldots F_{n_{ijt}}^{c_{n_i}} e^{u_{ijt}}$$

where:

Q = the quantity of electrical energy demanded
F_k = the level of the k independent variable (causal factor)
u = the error term
A, b, c_k = unknown parameters (n total)
i = the ith sector
j = the jth region
t = the tth period (year or month)
e = the base of natural logarithms

In this model, the constant short-run elasticities are the coeffients c_{k_i}, and, if required, the long-run elasticities can be calculated as $c_{k_i}/1 - b_i$. As already mentioned, we have preferred to use the more general Variable Elasticity Model.

The Variable Elasticity Model can be generally written as:

$$Q_{ijt} = A_{ij} Q_{ij(t-1)}^{b_{ij}} F_{1_{ijt}}^{c_{1_i}} \ldots F_{n_{ijt}}^{c_{n_i}} e^{d_{1_i} / F_{1_{ijt}}} \ldots e^{d_{n_i} / F_{n_{ijt}} u_{ijt}} e^{u_{ijt}}$$

where:

d_k = additional unknown parameters (n total)

Using a logarithmic transformation (log to the base e), we get:

$$\ln Q_{ijt} = a_{ij} + b_i \ln Q_{ij(t-1)} + \sum_{k=1}^{n} c_{k_i} \ln F_{k_{ijt}} + \sum_{k=1}^{n} d_{k_i} / F_{k_{ijt}} + u_{ijt}$$

where:

$a_{ij} = lnA_{ij}$

$u_{ijt} =$ the error term

The short-run elasticity of the kth factor in the ith sector is:

$$n_{ij} = c_{k_i} - d_{k_i} / F_{k_{ij}}$$

whereas, the long-run elasticity of a specific factor (if required) could be estimated by simply dividing its short-run elasticity by $1 - b_i$.

Hence, it is obvious that the elasticities' weights depend on the $F_{k_{ij}}$; since $F_{k_{ij}}$ differs between regions and sectors, $d_{k_i}/F_{k_{ij}}$ differs as well. As $F_{k_{ij}}$ decreases towards zero, the elasticity n_i approaches negative infinity, while as $F_{k_{ij}}$ increases, the elasticity n_i approaches c_{k_i} asymptotically (the long-run elasticity approaches infinity and $c_{k_i}/1 - b_i$ respectively). Since we expect all the predetermined variables to grow in the future in our model, we would like the elasticities to be fairly stable. Variations between regions in the elasticity of a particular factor can be explained by regional differences in the level of the corresponding factor. The present analysis is concerned only with the short-run elasticities as specified above, hence any reference to elasticities from now on should be read as being to short-run elasticities.

The term $Q_{ij(t-1)}$ is very important because it both captures the subjective factors such as tastes that influence the demand for electricity (that we assume remain relatively stable from one period to the other) and also it is a normalizing term, that allows us to take into consideration the geographical sizes of the different regions. The presence of the lagged dependent variable does, however, cause a serious autocorrelation problem with which we will deal later. Furthermore, bi is a very important parameter, since $1 - b_i$ is the demand response completed in the first period, and its expected value is: $0 < b_i < l$. If bi is close to zero, demand adjusts rapidly to changes in the independent variables, while if b_i is close to unity, the demand adjustment is slower.

Finally, an alternative specification of the Variable Elasticity Model for analyzing demand behaviour, as [Mount, Chapman and Tyrrell 73] state, could be the following:

$$Q_{ijt} = A_{ij} Q_{ij(t-1)}^{b_{ij}} F_{1_{ijt}}^{c_{1_i} + g_{1_i}/D_{ijt}} \ldots F_{n_{ijt}}^{c_{n_i} + g_{n_i}/D_{ijt}}$$
$$e^{g_{0_i}/D_{ijt}} e^{d_{1_i}/F_{1_{ijt}}} \ldots e^{d_{n_i}/F_{n_{ijt}}} e^{u_{ijt}}$$

where:
D_{ij} = the level of the shift factor
g_k = additional unknown parameters

In that case we allow for a shift variable, which usually is the mean January temperature, or the degree of urbanization. It has generally been implicitly assumed that only the constant term A_{ij} is influenced by those shift variables, i.e. that:

$$g_0 \neq 0 \text{ and } g_1 = g_2 = \ldots = g_n = 0$$

In our case, we have allowed the constant to differ between regions by using the relevant number of dummy variables, and so we could not incorporate shift factors in the same way. We have chosen instead to use variables to capture considerations which are represented by shift factors in other models.

Thus, the final shape of the model developed is:

$$\ln Q_{ijt} = a_{ij} + b_i \ln Q_{ij(t-1)} + c_{1_i} \ln P_{ijt} + c_{2_i} \ln Y_{ijt} + c_{3_i} \ln HT_{ijt} + \\ + c_{4_i} \ln AT_{ijt} + d_{1_i}/P_{ijt} + d_{2_i}/Y_{ijt} + d_{3_i}/HT_{ijt} + d_{4_i}/AT_{ijt} + u_{ijt}$$

where:

$\boldsymbol{Q_{ijt}}$ = quantity of electricity demanded from the ith sector in the jth region at the tth period. (in KWH)

$\boldsymbol{P_{ijt}}$ = price per electricity unit paid from the ith sector in the jth region at the tth period.

$\boldsymbol{Y_{jt}}$ = per capita personal disposable income of the jth region at the tth period. (representing the general economic activity and living standards).

$\boldsymbol{HT_{ijt}}$ = the per square foot heating energy required from the ith sector of the jth region at the tth period in order to maintain the reference temperature mentioned above (a proxy for the heating energy per square foot required to maintain a reference temperature of 65° F HT.)

AT_{ijt} = the per square foot air-conditioning energy required from the ith sector of the jth region at the tth period in order to maintain the reference temperature mentioned above. (a proxy for the air conditioning energy per square foot required to maintain a reference temperature of 70° F AT.)

Contrary to previous studies,[26] we do not include substitute fuel price as an independent variable because there are very limited fuel alternatives in Greece.

On the other hand, the value of the weather or the climate conditions was under consideration from the first instance, because even though Greece is considered to be a country with a very pleasant climate, people living there do demand very high temperatures in their homes and offices. As a result, a very great amount of electricity consumed is for heating purposes (or for air-conditioning purposes during the summer period). Hence, we have tried to allow for the climate effect in the electricity demand by using the aforementioned variables.

A number of other variables has been used in similar studies examining the demand for electricity. Unfortunately, most of those studies examine the demand of specific sectors (mostly that of the household sector), and use variables like the number of customers of the consuming sector under examination[27], or the number of different kinds of appliances[28] used. We did not follow this route in our model. Due to the fact that a large number of the different sectors was examined, and that in this study a single equation model was adopted, the variables used had to be of importance in all sectors.

A one period lagged quantity demanded is also included,[29] which represents the past pattern of consumers' behaviour as [Evans 69] considers appropriate. This is because the equilibrium level of the dependent varia-

---

26 Especially to those of: [Garbacz 83], [Houthakker 80], [Uri 75], [Westoby and McGuire 84].

27 Some of the studies using the number of customers as a variable are those of: [Gill and Maddala 76], [Halvorsen 75], [Uri 76].

28 Some appliance specific studies are the following: [Barnes, Gillingham and Hageman 81], [Fisher and Kaysen 62], [Parti and Parti 80].

29 The same variable appears in the following as well: [Balestra and Nerlove 66], [Gill and Maddala 76], [Houthakker 80], [Ubogn 85], [Uri 75], [Uri 76].

ble will not be attained until some time after the change in the independent variable has occurred. Consequently, it is necessary to superimpose on the original model specification, a second hypothesis concerning the time patterns of adjustment of dependent to independent variables. The lag reflects the relationship between the use of electrical energy and existing stocks of electrical appliances and machinery. The level of these stocks depends on past and current decisions, and therefore on the size of past and present independent variables. If the lag in demand was ignored, the estimates of the elasticities would be both biased[30] and inconsistent.[31]

Per capita personal disposable income[32] is inserted in our model as the income variable,[33] as [Evans 69] suggests[34]. If instead of per capita constant income data, we had used total income data in constant prices, there would be no important difference. Use of the latter formulation is important only in countries where there are many immigrants (who have different habits from the native residents), and therefore not in Greece.

Data on the price of electricity are measured on average constant per KWH prices. Even though the economic theory suggests that the individual always bases his economic decisions on marginal values,[35] the average prices are in practical terms those that are important on the supply side for the utility industries, since the regulatory agencies' main goal is to maintain stability between average prices and average costs by altering their existing rate schedule.[36] In the meantime, [Taylor 75] argues that

---

30 See [Theil 57].

31 See [Grilliches 67].

32 The value of Personal Disposable Income was calculated as follows: Personal Disposable Income = National Income + Direct Taxes on Income + Government Income from Property and Entrepreneurship + Savings of Corporation − Government Current Transfers to Households (Net) − Interest on Public Debt − Current Transfers to Households from the Rest of the World (Net).

33 The importance of the income elasticity of demand for electricity is emphasized by [Hsiao and Mountain 85].

34 The variable appears in the same way in the following studies: [Gill and Maddala 76], [Halvorsen 75], [Houthakker 80], [Ubogn 85].

35 Studies using marginal prices are: [Halvorsen 75], [Houthakker 80], [Walker 79].

36 Studies using average prices are: [Donnely and Diesendorf 85], [Ubogn 85], [Uri 75], [Uri 76].

both average and marginal prices should be included as predictors in the demand function. Specifically, he states that both quantities should be taken from actual data, and not to be calculated ex post, as usually is the case. Accordingly, the marginal price should refer to the last block consumed, whereas the average price should refer to the consumption up to the final block, without including it (or alternatively, the total expenditure on electricity up to the last block could be replace the average price. Thus, whichever quantity used, the variable would measure the income effect that arises from the intra-marginal price changes, and the price effect would be measured from the marginal price.[37] On the other hand, [Wilson 71] argues that there is no difference whether using average prices or estimates of marginal ones (derived from typical billing).[38]

The temperature is inserted in the model through the parameters of air-conditioning energy per square foot required to maintain a reference temperature of 70° F, and heating energy per square foot required to maintain a reference temperature of 65° F. This is done through a functional relationship used by [Parti and Parti 80], that transforms average high and low temperatures into the aforementioned variables.], according to which the average low and average high temperatures serve to estimate the heating energy HT per square foot required to maintain a reference temperature of 65° F, and the air-conditioning energy AT per square foot required to maintain a reference temperature of 70° F, according to the formula:

- If the average low temperature (LO) is less than 65° F, and the average high temperature (HI) is greater than 70° F:

$$HT = 12 * \left[(65 - LO)^2\right] \Big/ (HI + LO)$$

and

$$AT = 12 * \left[(HI - 75)^2\right] \Big/ (HI - LO)$$

- If the low temperature is greater or equal to 65° F:

$$HT = 0$$

37 Both marginal and average prices are used in many studies, like that of [Garbacz 83].

38 See also [Cicchetti and Smith 75].

- If the high temperature is less or equal to 70° F:

$$AT = 0$$

- Finally, if the high temperature is less than or equal to 65° F:

$$HT = (24 * 65) - 12 * (HI + LO)$$

Alternatives we considered include an index of the average temperature, or the number of degree cooling and degree heating days in the period specified (month or year)[39]. We should also emphasize that it was expected that those variables will affect some of the consuming sectors examined in this study (namely the household, public, industrial and commercial sectors) more than others, because a significant part of their total consumption is spent on heating and air-conditioning. Since the consumption of those sectors (as a total) is proportionally much higher than that of those remaining, these proxies are included in the model without seriously affecting its accuracy.

All variables used in the present model are measured in terms of constant base year prices, for two reasons:

- As [Evans 69] explicitly states: *from an economic point of view, consumers make decisions in terms of their real consumption relative to their real income. If all money incomes and prices of goods and services were to double simultaneously, consumers would still spend the same proportion of their income. On the other hand, if income were to double in the short-run, while prices stayed constant, the consumption to income ratio would decrease until individuals adjusted their spending patterns to the additional real income*. (page 55)
- From a statistical point of view: *if income and consumption both rise only because of price increases, this would introduce yet another element of spurious correlation into the relationship of these two variables. The rise in money consumption and money income would both be due to price increases, suggesting a spurious positive correlation, meanwhile, consumers would be purchasing the same quantity of goods and services with the same real income*. (page 55)

---

39 The number of degree cooling and degree heating days are the most frequently used. Especially: [Donnely and Diesendorf 85], [Gill and Maddala 76], [Halvorsen 75], [Houthakker 80], [Ubogn 85], [Uri 75], [Walker 79].

Furthermore, the correct deflator for each variable was chosen.

- In order to deflate the price of electricity, the relevant energy price index is used, but since there are no relevant regional price indices, we use the national one for all regions.
- In order to deflate the per capita personal disposable income, the choice was between the CPI (Consumers Price Index) and the GNP (Gross National Product) deflator. Following the suggestions in [Evans 69], the consumption index is used, because of the "purchasing power" argument, according to which: *personal disposable income ought to be deflated by a price index measuring the amount of goods that can be bought in physical terms*. (page 56)

The set of data being adopted was kindly provided by PPC, and incorporates monthly and yearly data covering a 10 year period, dividing Greece in 5 regions and allowing for 19 9 different consuming sectors. So, only by pooling together time-series and cross-sectional observations adequate estimations are derived, since the relative error variance of the resulting elasticity estimates decreases, as [Kuh 59] states, and hence a gain in efficiency occurs.[40] On the other hand, by using cross-sectional data we have to face what is potentially a very serious problem: the Constant Elasticity Model can be used only when the elasticity of each variable is equal in all regions, but this is an unrealistic assumption in our case, and so its results would be very arbitrary.[41] This is especially so, because the level of development differs among regions drastically, so we could not expect, for example, the income elasticity of the agricultural sector to be the same in all regions (some of which are highly industrialized). The difficulty can, however, be overcome by using a Variable Elasticity Model, in order to capture some of the heterogeneity between regions. In this case, we attribute the elasticity differences to the differences in the level of the specific factor in the particular region. [Balestra and Nerlove 66] had proposed a technique for pooling together cross-sectional data and time-series, based on the assumption that the error term is composed of one component associated with the cross-sectional units and another one associated with

40 Similar studies are those of: [Breiner and Karni 83], [Gill and Tyrrell 74], [Iwayemi 81], [Starr 78].

41 See [Christ 66].

the time-series, whereas [Chetty 68] argued that there is a third component varying in both dimensions, as well. We did not use Balestra and Nerlove's method for two reasons:

1. In that method, the efficiency of estimation increases if the residual variation is relative large. Since the residual variation is not large. in our model, the estimates we would get would not have been efficient.
2. Each region has a unique share of production and allocation to the total, which is depicted in its demand for electrical energy. Assuming that the constant term remains the same, as this method requires, would result in losing this uniqueness, which would not be correct.

Consequently, since the behaviour of the error term is what determines the procedure with the best statistical results, we discarded the "Variance Component Model" in favour of the "Separate Constants Model". We introduced Dummy Variables that identified each of the 5 regions examined in our model. (Of course, Greece as a total was not included into the specification). In addition, in order to obtain determinate estimates (since otherwise we would have a case of complete multicollinearity)[42], we included the additional constraint of omitting the fifth dummy. Finally, the estimated values of the dummy variables were collapsed into the constant term, explaining the difference in constants.[43] Then, the results obtained were used to estimate the price elasticities in region- and sector-specific level, according to our model specification.

Demand for electricity for some purposes, in some regions, is recorded in the official data as zero. In order to undertake our analysis without grouping the data, we arbitrarily replaced all zero observations by 0.0001, on the assumption that the zeros represented very low, but non-zero amounts. If this assumption was wrong, our results may have been badly affected.[44]

[42] For more details see [Thomas 85].

[43] See [Suits 57].

[44] See section 6.2 below.

2.3 Single Equation Analysis Model

In order to specify more precisely the model that is to be used in this study, we should remark that it is a "Single Equation Analysis" model. It was firstly developed by [Fox 58]. [Schultz 38] eliminated demand shifts from the data. Fox's development, was to include the shift factor in the demand equation, which therefore became[45]

$$\underline{q}_i = bp_i + ny_i + lz_i + \underline{u}_i$$

where:

y = income
q = quantity
p = price
u = error term
z = any factor making for demand shifts (e.g. the supply of substitute commodities, depending on the product under examination)
b, n, l = parameters which are deviations from the mean of natural logarithms and hence stand for elasticities.

Fox's demand equation was complimented not by a supply equation, but by the statement:

q: predetermined

which resulted in changing the form of the demand equation, since variable q_i was not dependent (and hence stochastic), but p_i was the only dependent variable, into:

$$q_i = b\underline{p}_i + ny_i + lz_i + \underline{u}_i$$

Therefore, by transferring the dependent variable to the left-hand side we obtain the "reduced" form:

$$\underline{p}_i = cq_i + dy_i + mz_i + \underline{v}_i$$

where:

$c = l/b$

45 From now onwards, we adopt the "Dutch Convention" for underlining random variables, following [Hemelrijk 66].

$d = -n/b$

$m = -l/b$

$v_i = -u_i/b$

in which the parameters c, d, $m$can be estimated by least squares regression, since all variables in the right-hand side are predetermined. It is an important advantage that in this method there is no identification problem. The corresponding structural estimates are rapidly derived. The reduced form coefficient c is called "price flexibility of demand" and by inversing it we can indirectly estimate the b coefficients, and hence the price elasticity of demand.

This way of estimating is equivalent to the second regression in a simple two variables analysis of quantity and price data alone, as Schultz's model stated:

$$\text{DEMAND:} \quad \underline{q}_i = bp_i + \underline{u}_i \qquad b < 0$$

$$\text{SUPPLY:} \quad \underline{q}_i = ap_i + \underline{v}_i \qquad a > 0$$

where b, a are the price elasticities of demand and supply respectively. By solving the model, we obtain the reduced form:

$$\underline{p}_i = \frac{\underline{u}_i - \underline{v}_i}{a - b}$$

$$\underline{q}_i = \frac{a\underline{u}_i - b\underline{v}_i}{a - b}$$

Hence, the second order regression coefficient will be:

$$\underline{h} = \sum \underline{q}^2 \Big/ \sum \underline{pq}$$

and, by substituting it into the second set of equations and using the independence of u_i, v_i:

$$P\lim(\underline{h}) = a^2\sigma_u^2 + b^2\sigma_v^2 / a\sigma_u^2 + b\sigma_v^2$$

where:

σ_u^2 = variance of u

σ_v^2 = variance of v

Since (from the preliminary assumptions) supply is perfectly inelastic, then $a = 0$, and so by substituting it we get $P\lim(h) = b$.

We therefore observe the obvious advantage of the indirect estimation of b from the corresponding "price flexibility". Furthermore, since $P\lim(h) = b$ holds irrespectively to the relative magnitudes of σ_u^2 and σ_v^2, it is clear that the introduction of demand shift factors in Fox's demand equation was not needed to reduce bias (unlike in Schultz's model). In fact, y serves to obtain an estimate of income elasticity of demand, and both y and z contribute to the precision of estimates by reducing the residual variation.

[Cramer 71] states that the single equation analysis as used by [Fox 58], continues to apply in the case of demand for public utilities, as it is shown in the analysis for electricity demand by [Fisher and Kaysen 62] and the studies of demand for public transport by [Dewolff 37] and [Fase 68]. This is so because of two reasons. Firstly, public utilities are among the few industrial products for which reliable price and quantity data are available. In addition, their particular market conditions favour the use of a simple regression of quantity on income and price. That occurs because, as we will explain in the next paragraph, the prices are mostly set under public regulation policies oriented towards serving the public interest, rather than cost or supply considerations. In other words, they are non-profit oriented enterprises, functioning under the motive of maximizing production for the fulfillment of social welfare. Hence, price may be regarded as a predetermined variable, at any rate in the short run of annual data, and quantity is justified to be the dependent variable, by using Fox's argument "mutatis mutandis". So, in our model of electrical energy demand, the market operates via quantity adjustments, as opposed to the case where the quantity is set and price varies.

3. The Estimation Results and Conclusions

3.1 Bibliography Review

Relevant studies' background is exceptionally limited, because most of the studies are sector-specific, and usually examine household sector data only.

- The most important studies examining household data are presented, together with a brief description of their assumptions and results, in Table 3.1.

- Studies dealing with the industrial sector are outlined in the same way in Table 3.2.
- Finally, studies dealing with the demand for electricity in the commercial sector are summarized in Table 3.3.

The results obtained from such studies are not directly comparable with ours, for many reasons. First, these studies can use the exact variables appropriate for analyzing the demand of the specific sector, whereas we have included only general causal factors as independent variables. Apart from that, which is the main difference, it should be noted that some of the studies cited refer to long-run and others to short-run estimates. Finally, there are differences in the spatial approximation of the studies, since they do not analyze Greek data.[46] This is very important, since the habits of residents of different countries are quite distinct, and they also significantly affect their consumption formation. Unfortunately, there are very few studies for Greece,[47] and those that exist are concerned with yearly data, and are also sector-specific, so they are not very appropriate for comparisons.

Still, there are some studies that deal with more than one consuming sector at the time, like those of [Ubogn 85] and [Uri 75]. In the first case the study is dealing only with the household, industrial commercial sector, each of those equations is specified separately, and there is no regional setting. In the second case, the estimation procedure is quite similar to the one adopted in the present study, since it involves a single equation analysis of pooled cross-section and time-series data, but there is no allowance for the climate effects and only the same three sectors are examined. Consequently, a comparison can only give general indications of the order of magnitude and sign the parameters should have.

With the limitations we have discussed, we can use these other studies to

---

46 Studies performed for other countries are those of: [Breiner and Karni 83], [Common and Peirson 79], [Doctor and Anderson 73], [Dunkerley 82], [Halvorsen 73], [Humphrey and Stanislaw 79], [Iwayemi 81].

47 See [Rigas 82].

form some expectations about the results of the model developed in this study.[48]

Because of the use of time-series and the existence of so many explanatory variables, it would be reasonable to obtain a quite high value for the coefficient of multiple determination (*R*-squared), ranging perhaps from 0.80 to 0.99. That would reveal the proportion of the variation of the dependent variable explained by the variation of the independent variables, and a value close to unity would support the validity of the model examined.

The sign of the regression coefficients indicate a direct or indirect (if plus or minus respectively) variation between the specific independent variable and the dependent variable. In our case we should expect:

- The coefficient of the lagged dependent variable should range between zero and unity, since it shows how rapidly the demand adjusts to changes in the independent variables.
- The price coefficient, which since we have used logarithms represents elasticity, should be negative (since the price is inversely related to the quantity consumed), with size varying among consuming sectors.
- The income coefficient should be positive (since income is directly related to the quantity, consumed) and its size should be below unity, varying among sectors.
- The coefficients of the two weather variables should also be positive (since the more energy required for heating or cooling purposes, the higher the consumption will be), and of relatively small size.

3.2 Estimation Results

In most of our equations the coefficients of multiple determination, as shown in program named are quite satisfactory, according to our expectations. They range from 0.856 to 0.999, with the exception of the agricultural sector, the sector that includes the electricity demanded for street lighting purposes and the public sector demand. These are quite expected,

[48] See [Labys 82].

since the variables included in our model can be anticipated to be of limited relevance to those sectors. Specifically, as can be seen, this is because of the unimportance of certain variables in each of them, which means that these variables should have been dropped or replaced by others. For example, in the agricultural sector, the income variable is not significant, and this results in a poor *R*-squared.

The *F*-statistic in all equations is significant at a 99% level; this means that at that level not all the partial regression coefficients are zero at a time.

The coefficient of the lagged dependent variable usually has the right sign and size, ranging from 0.10 to 0.60 depending on the sector examined, and is also statistically significant. This shows that a very important part of the demand response $(l - b_i)$ is completed in the first period as we expected. The only sectors where this coefficient seems to be of wrong size are those for Street Lighting, Agricultural Low Voltage and some voltages of the Public Use, but as we have already mentioned, this could be attributed to specification problems, as follows:

In the Household Sector, both price and income variables are statistically insignificant. On the other hand, the temperature variables are significant at a 99% level. So, we can observe some misspecification problem here. Finally, the coefficient of the lagged dependent variable, has the right size and sign, and it is statistically significant. The fact that its size is only 0.13 shows that the biggest part of the demand adjustment is completed in the first period, which must be attributed to the particular consumption behavior of the Greeks (since, in other countries, studies have shown a coefficient closer to unity).

In the Agricultural Sector, either considered as a Total, or as its Low, or Medium Voltages, we observe that the price appears to be exceptionally significant together with the weather variables. It is worrying that the size and the sign of the price parameter are not as expected. Furthermore, income is insignificant. Hence, a specification problem seems to appear again, although in the particular case we believe that the remedy would be the use of different specification of income, e.g. per capita agricultural income, or the share of agricultural production to the total GNP could be used instead. Furthermore, the coefficient of the lagged quantity is exceptionally small, although with the right sign and statistically significant, which shows a very quick adjustment behavior.

In the Commercial Sector, we have the correct size, but not sign for the price variable. The income variable has the anticipated sign, but not size (with the exception of the Low Voltage component, where the opposite holds). For both these variables, their significance change among the components of the sector (Low and Medium Voltage); this is quite reasonable, since different voltages apply to different uses. The weather variables are significant, which is expected. Generally, we seem to have the multicollinearity problem again. The coefficient of the lagged dependent variable is very small, although statistically significant; this is more reasonable for this sector, since in this case it is used as intermediate good as well (which is not the case in the household sector).

As far as the Street Lighting Sector is concerned, it is very clear that the variables included are not the appropriate ones. The nature of this sector is such as to prevent it from being considered in a general model like ours, and hence its demand should be considered individually, using a quite different variable specification. So, we think this sector should be discounted in any further considerations.

In the demand for electricity from the Public Sector, we observe that the previous period demand is highly significant, though of the wrong sign (apart from the Medium Voltage component, where the sign is correct), when considered as a Total, and in its Low and Medium Voltage uses. Specification problems can however be expected for this sector, which is probably less price-sensitive than the private sector.

In the Sector concerning the demand for Pulling purposes, we also consider it more appropriate that it would be studied separately, since the variables used as explanatory factors do not really specify its demand. Certainly, our equation performs very badly on various criteria.

In the Industrial Sector as a Total, as well as in its components Low, Medium and High Voltage, we observe that although price is significant and has the right size, it has the wrong sign. Income is not significant, but this is reasonable, because of the very nature of the sector. Hence, if we were to replace income data with something more relevant to this case, like the share of the industrial products in the GNP, we believe we would get a better fit.

Finally, as far as the demand as a Total, or in its components of Low, Medium and High Voltage is concerned, we observe that the price and income variables have the correct size and are significant, but not with the correct sign. Therefore, once again we conclude that some specification tests, as well as test for multicollinearity presence, should be performed. Finally, the coefficient of the lagged dependent variable is exceptionally small, but has the right sign and is statistically significant; if this result were to survive a respecification of the model, it would be obvious that the adjustment of the dependent variable to changes in the independent variable is very quick.

Separate estimates for each consuming sector performed for the demand of Greece as a total, give broadly similar results. Specifically, the *R*-squared usually ranges from 0.60-0.90, although in some sectors it is particularly low, 0.30-0.50, (e.g. the Street Lighting sector); still, those sectors are those in which we have already had difficulties. What is interesting, is that the *R*-squared we get in this way is generally lower than before. The *F*-statistic is significant in all sectors. The size of the coefficient of the lagged dependent variable is of the same magnitude as above and its sign is wrong in the same sectors (e.g. the Public Sector, the Street Lighting Sector, etc.). The coefficients of the price variable obtained are generally of smaller size than before, but have the correct sign (with the exception of the Public Sector —where, as already explained, it is quite reasonable— and the Low and High Voltage components of the Industrial Sector). On the other hand, the results obtained for the income coefficients are most unreasonable, since we often get elasticities greater than unity (e.g. in the Household Sector). That shows that the pooling of data is perhaps a more appropriate specification. Finally, the results obtained for the weather variables were much the same as those recorded above. The similarity of the two sets of results strengthens the argument that if the appropriate tests are performed, it is quite possible that the model estimates will be correct.

The price elasticities for all different consuming sectors and all regions, as specified by our model using monthly data, are presented in Table 3.4. The main conclusions drawn can be summarized as follows:

- The sizes of the elasticities obtained are quite reasonable, but their signs and statistical significances vary among sectors and regions.
- The price level of each region affects the size of the elasticity obtained, so the proportional differences in price levels correspond to those in elasticities estimated.
- The regional elasticities are often different for those obtained for Greece as a total (e.g. in the Agricultural Sector, the Commercial Sector, etc.), which supports the purpose of a regionally disaggregated analysis.

- Furthermore, the analysis of each sector separately (even for the different voltage categories of each sector), is justified from the results obtained, since e.g. the elasticities estimated for the Household Sector are different from those estimated for the Agricultural Sector, and in the latter, the price elasticities of the different voltages are quite distinct. Finally, we should mention that the elasticities obtained are of small magnitude (compared with what we would expect), and they generally do not have the right sign (with the exception of Household, Industrial Low, Total Medium voltage, and Street Lighting Sectors); as we have already noted, we think this is due to specification problems of the model employed. This supports the case we have already made, that some specification tests should be performed on our variables.
- Multicollinearity, which is due to the existence of the lagged dependent variable in the right-hand side of our model. As we have already stated, as far as the coefficient of this variable is concerned, the fact that its size is quite small in all sectors could be attributable to the particular consumer behavior of Greeks.

The results obtained using yearly data are all in the same general lines. Again we have obtained high *R*-squared and highly significant *F*-statistic for all sectors, but many of the individual variables are not significant, and their coefficients do not have the right form. The magnitudes of the variables are generally greater than those obtained from the monthly analysis, but they are often greater than unity (e.g. in the Agricultural Sector both price and income elasticities are greater than unity), which is unreasonable. Furthermore, the coefficient of the dependent variable is usually greater than that obtained from the monthly analysis. This is unexpected, since the period over which the consumer response is completed is larger. In some cases, e.g. in the Commercial Sector, the size of that coefficient is greater than unity. Hence, these results clearly suggest, that the yearly pattern is not the appropriate one for analyzing the demand behaviour for electricity. The misspecification problem is particularly obvious. Finally, the regional shifts in demand are highly important all through the analysis; this again supports our decision to undertake disaggregated analysis.

The price elasticities as specified from our model are calculated for all consuming sectors and all regions are presented in the Table 3.5. The elasticities obtained do not have the right sign because of the aforementioned problems. Still, some interesting conclusions can be drawn from them.

- First of all, it is clear that the analysis in a sectoral disaggregated level is useful even for analyzing the different voltages of each sector separately, since the elasticities obtained for each of them are quite distinct.
- Then, the regional disaggregation is well founded, since the differences in the elasticities among regions are particularly obvious, e.g. in the Agricultural Low Sector.
- Finally, the sizes of the elasticities obtained are very low, which strengthens the argument for using a different temporal setting, the monthly analysis.

Table 3.1: Electricity by type of model and data

Research study	*Sample* [a]	*Price elasticity* [b]		*Income elasticity* [b]	
		Short-run	*Long-run*	*Short-run*	*Long-run*
I. Reduced-Form Models					
A. Static consumption models					
1. Aggregate level data					
a) Average prices					
Fisher, Kaysen (1962)	Time series: states, 1946-57	−0.16 to −0.24		0.07 to 0.33	
Moore (1970)	Cross-section: 407 utilities, 1963		−1.02		
Wilson (1971)	Cross-section: 77 cities, 1966		−1.33		n.s.
Anderson (1973)	Cross-section: states, 1960, 1970		−1.07, −1.28		1.06, 0.67
CRA (1976)	Pooled: stales, 1966-72		−1.20		0.48
Halvorsen (1978)	Pooled: states, 1961-69		−1.14		0.52
b) Marginal prices					
Lacy, Street (1975)	Times series: Alabama Power Co., 1967-74	−0.45		1.87	
Wills (1977)	Cross-section: Mass. utilities, 1975	−0.08		−0.32	
Halvorsen (1978)	Pooled: states, 1961-69		−1.53		0.72
McFadden, Puig (1975)	Pooled: states, 1961-69		−0.48		0.99
2. Disaggregated level data					
a) Average prices: none					
b) Marginal prices					
Acton, Mitchell, Mowill (1976)	Pooled: monthly, Los Angeles County, 1972-74		−0.70		0.40
Hewlett (1977)	Cross-section: house-hold survey, 1973 & 1975	−0.14		0.07	

(to be continued in page 63)

(continued from page 62)

Research study	*Sample* [a]	*Price elasticity* [b]		*Income elasticity* [b]	
		Short-run	*Long-run*	*Short-run*	*Long-run*
B. Dynamic consumption models					
1. Aggregate level data					
a) Average prices					
Houthakker, Taylor (1970)	Time series: U.S., 1946-64	−0.13	−1.89	0.13	1.94
Uri (1976)	Time series: monthly, U.S., 1971-75	−0.35		2.00	
Griffin (1974)	Time series: U.S., 1951-71	−0.06	−0.52	0.06	0.88
Mount, Chapman,	Pooled: states, 1946-70 (3 versions)	−0.14	−1.21	0.03	0.30
Tyrrell (1973)		−0.14	−1.20	0.02	0.20
		−0.36	−1.24	0.06	0.21
Gill, Maddala (1976)	Pooled: monthly, TVA area,	−0.49	−0.57	0.10	0.12
	1962-67 and 1968-72	−0.34	−0.62	0.12	0.22
Colin, Hirst, Jackson (1977)	Pooled: states, 1951-74 and 1969-74	−0.14	−1.16	0.02	0.16
		−0.14	−0.47	0.16	0.56
b) Marginal prices					
Houthakker, Verleger,	Pooled: states, 1960-71 (3 prices)	−0.09	−1.19	0.13	1.63
Sheehan (1974)		−0.03	−0.44	0.14	2.20
		−0.09	−1.02	0.14	1.64
Taylor, Blattenberger,	Pooled: states, 1956-72	−0.08	−0.82	0.10	1.08
Verleger (1977)					
2. Disaggregated level data					
a) Average prices: none					
b) Marginal prices					
Hewlett (1977)	Pooled: household survey, 1973 and 1975	−0.16	−0.45	n.s.	n.s.

(to be continued in page 64)

(continued from page 63)

Research study	Sample[a]	Price elasticity[b]		Income elasticity[b]	
		Short-run	Long-run	Short-run	Long-run
C. Fuel shares models					
1. Static versions					
Chern (1976)	Pooled: states, 1971-72		−1.34		0.40
2. Dynamic versions					
Baughman, Joskow (1975)	Pooled: states, 1968-72	−0.19	−1.00	n.s.	n.s.
DOE (1978)	Pooled: regions, 1960-75	−0.18 to −0.54	−0.72 to −2.10	n.s.	n.s.
II. Structural Models					
A. Aggregate level data					
1. Average prices					
Fisher, Kaysen (1962)	Time series: states, 1946-57		n.s.	n.s.	
Anderson (1973)	Cross-section: stales, 1960 and 1970		−1.07		1.06
			−1.28		0.67
2. Marginal prices					
Taylor, Blattenberger, Verleger (1977)	Pooled: states, 1961-72	−0.16	−0.46	0.22	1.00
B. Disaggregated level data					
1. Average prices: none					
2. Marginal prices					
McFadden, Puig, Kirshner (1977)	Cross-section: house-hold survey, 1975	−0.25	−0.66	0.21	0.39

[a] Observation periods are annual except where indicated otherwise.

Table 3.2: Summary of aggregate price and income elasticities of industrial demand for electricity

Research study	*Sampl-e*[a]	*Price elasticity*[b]		*Income elasticity*[b]	
		Short-run	*Long-run*	*Short-run*	*Long-run*
I. Static Consumption Models					
Asher, Habermann (1978)	Time series and Cross-section: 63 utilities, 1971-75	−0.20	−0.74	n.s.	n.s.
Halvorsen (1978)	Cross-section: states, 1969		−1.24		0.68
II. Dynamic Consumption Models					
Mount, Chapman, Tyrrell (1973)	Pooled: states, 1946-70 (3 versions)	−0.20	−1.79	0.08	0.73
		−0.22	−1.82	0.06	0.51
		−1.36	−1.74	0.51	0.65
CRA (1976)	Pooled: states, 1958-73	−0.10	−1.02	0.07	0.70
Uri (1976)	Time series: monthly, U.S., 1971-75	−0.12		0.87	
Griffin (1974)	Time series: annual, U.S., 1951-71	−0.04	−0.51		
III. Fuel Shares Models					
Baughman, Zerhoot (1973)	Pooled: annual, states, 1968-72	−0.11	−1.28		
DOE (1978)	Pooled: annual, states, 1960-75	−0.17	−0.75		

[a] The estimates given are statistically significant at the 0.03 level. An entry o n.s. indicates not significant. A blank space means no estimate was attempted.

Table 3.3: Summary of estimated price and income elasticities of commercial demand for electricity

Research study	*Sampl-e*[a]	*Price elasticity*[b]		*Income elasticity*[b]	
		Short-run	*Long-run*	*Short-run*	*Long-run*
I. Reduced-Form Models					
A. Static consumption models					
Asher and Habermann (1978)	Pooled: monthly, 63 utility areas, 1971-76	−0.25	−1.20	n.s.	n.s.
Halvorsen (1978)	Cross-section: annual, states, 1969 (two price equations)		−1.16 −0.56		1.38 1.15
B. Dynamic consumption models					
Mount, Chapman, Tyrrell (1973)	Pooled: annual, states, 1946-70 (3 versions)	−0.20 −0.17 −1.18	−1.60 −1.36 −1.45	0.10 0.11 0.72	0.80 0.86 0.88
Uri (1976)	Time series: monthly, U.S., 1971-75	n.s.	n.s.	n.s.	n.s.
C. Fuel shares model					
DOE (1978)	Pooled: annual, 10 regions, 1960-75	−0.30 to −0.66	−0.94 to −1.54	n.s.	n.s.
II. Structural Models: none					

[a] The estimates given are statistically significant at the 0.05 level. An entry of n.s. indicates not significant. A blank, space means no estimate was attempted or reported.

Table 3.4: Estimated price elasticities of monthly data

	ATTICA	CENTRAL GREECE	MACEDONIA-THRACE	PELOPONNESE-HEPIRUS	ISLANDS	GREECE
HOUSEHOLD	−0, 291	−0, 291	−0, 291	−0, 291	−0, 291	−0, 208
AGRICULTURAL TOT	0,937	0,937	0,937	0,937	0,937	0,307
AGRICULTURAL LV	0,990	0,990	0,990	0,990	0,990	0,130
AGRICULTURAL MV	1,328	1,328	1,328	1,328	1,370	−0, 527
COMMERCIAL TOT	0,289	0,289	0,289	0,289	0,289	−0, 118
COMMERCIAL LV	0,370	0,370	0,370	0,370	0,370	0,012
COMMERCIAL MV	0,041	0,041	0,041	0,041	0,041	−0, 452
STREET LIGHTING	−2, 218	−2, 218	−2, 218	−2, 218	−2, 218	−4, 978
PUBLIC SECTOR TOT	0,181	0,181	0,181	0,181	0,181	0,338
PUBLIC SECTOR LV	1,413	1,413	1,413	1,413	1,413	1,317
PUBLIC SECTOR MV	0,255	0,255	0,255	0,255	0,255	−0, 128
PULLING	2,271	2,265	2,265	2,265	2,265	−0, 338
INDUSTRIAL TOT	0,100	0,100	0,100	0,100	0,100	0,461
INDUSTRIAL LV	−0, 044	−0, 044	−0, 044	−0, 044	−0, 044	−0, 083
INDUSTRIAL MV	−0, 185	−0, 185	−0, 185	−0, 185	−0, 185	0,082
INDUSTRIAL LV	0,025	0,025	0,025	0,025	0,025	0,040
GREECE LV	−0, 075	−0, 074	−0, 073	−0, 075	−0, 075	−0, 074
GREECE MV	−0, 177	−0, 177	−0, 177	−0, 177	−0, 177	−0, 120
GREECE TOT	0,178	0,178	0,178	0,178	0,178	0,815

Table 3.5: Estimated price elasticities of yearly data

	ATTICA	CENTRAL GREECE	MACEDONIA-THRACE	PELOPONNESE-HEPIRUS	ISLANDS
HOUSEHOLD	0,063	0,063	0,063	0,063	0,063
AGRICULTURAL TOT	−0, 001	−0, 001	−0, 001	−0, 001	−0, 001
AGRICULTURAL LV	1,024	1,024	1,024	1,024	1,024
AGRICULTURAL MV	1,596	1,596	1,596	1,596	1,626
COMMERCIAL TOT	0,174	0,174	0,174	0,174	0,174
COMMERCIAL LV	0,089	0,089	0,089	0,089	0,089
COMMERCIAL MV	−0, 080	−0, 079	−0, 079	−0, 079	−0, 079
STREET LIGHTING	0,054	0,054	0,054	0,054	0,054
PUBLIC SECTOR TOT	0,158	0,158	0,158	0,158	0,158
PUBLIC SECTOR LV	−0, 025	−0, 025	−0, 025	−0, 025	−0, 025
PUBLIC SECTOR MV	−0, 074	−0, 074	−0, 074	−0, 074	−0, 074
PULLING	0,393	0,393	0,393	0,393	0,393
INDUSTRIAL TOT	0,862	0,861	0,862	0,861	0,862
INDUSTRIAL LV	0,513	0,513	0,513	0,513	0,513
INDUSTRIAL MV	0,912	0,912	0,912	0,912	0,912
INDUSTRIAL LV	0,069	0,064	0,069	0,069	−0, 087
GREECE LV	0,184	0,184	0,184	0,184	0,184
GREECE MV	0,030	0,030	0,030	0,030	0,030
GREECE TOT	0,104	0,104	0,104	0,104	0,104

Bibliography

[Acton, Mitchell and Mowill 76]
J.P. Acton, B.M. Mitchell and R.S. Mowill. *Residential demand for electricity in Los-Angeles: An econometric study of disaggregated data*. Technical Report R-1899-NSF, Rand Corporation, 1976.

[Anderson 72]
K.P. Anderson. *Residential demand for electricity: Econometric estimates for California and the United States*. Technical Report R-905-NSF, Rand Corporation, January, 1972.

[Anderson 73]
K.P. Anderson. *Residential energy use: An econometric analysis*. Technical Report R-1296-NSF, Rand Corporation, 1973.

[Anderson 74]
K.P. Anderson. *The price elasticity of residential energy use*. Technical Report R-1580, Rand Corporation, February, 1974.

[Asher and Habermann 78]
H. Asher and R. Habermann. *Analysis of recent fluctuations in electricity consumption*. Technical Report CFESR-77-3, General Electric Co, Center for Energy Systems, 1978.

[Balestra and Nerlove 66]
P. Balestra and M. Nerlove. Pooling cross-section and time-series data in the estimation of a dynamic model. *Econometrica* 34(3), July, 1966.

[Barnes, Gillingham and Hageman 81]
R. Barnes, R. Gillingham and R. Hageman. The short-run residential demand for electricity. *The Review of Economics and Statistics* 63, 1981.

[Barten 64]
A.P. Barten. Consumer demand functions under conditions of almost additive preferences. *Econometrica* 32, 1964.

[Baughman and Joskow 75]
M. Baughman and P. Joskow. *Energy consumption and fuel choice by residential and commercial consumers in the United States*. Technical Report MIT-EL-75-024, Massachusetts Institute of Technology Energy Laboratory, 1975.

[Baughman and Zerhoot 75]
M. Baughman and F. Zerhoot. *Interfuel substitution in the consumption of energy in the United States, Part 2: Industrial sector*. Technical Report MIT-EL-75-007, Massachusetts Institute of Technology Energy Laboratory, 1975.

[Baxter and Rees 68]
R.E. Baxter and R. Rees. Analysis of the industrial demand for electricity. *The Economic Journal* 78(310), June, 1968.

[Beglari and Langton 73]
F. Beglari and M.A. Langton. *Model building with particular reference to power system planning: The improved Z-substitutes method.* IPC Science and TECH Press, Buildord, U.K., 1973.

[Berg and Roth 76]
S.V. Berg and W.E. Roth. Some remarks on residential electricity consumption and social rate restructuring. *The Bell Journal of Economics* 7, 1976.

[Berman and Hammer 73]
M.B. Berman and M.J. Hammer. *The impact of electricity price increases on income groups: A case study for Los Angeles*. Technical Report R-1102-NSF/CSA, Rand Corporation, March, 1973.

[Berman, Hammer and Tihansky 72]
M.B. Berman, M.J. Hammer and D.P. Tihansky. *The impact of electricity price increases on income groups: Western United States and California*. Technical Report R-1050-NSF/CSA, Rand Corporation, November, 1972.

[Betancourt 81]
R.R. Betancourt. An econometric analysis of peak electricity demand in the short-run. *Energy Economics* 3(l), January, 1981.

[Boiteux 56]
M. Boiteux. Sur la gestion des monopoles publics: Astreints a l'equilibre budgetaire. *Econometrica*, January, 1956.

[Breiner and Karni 83]
A. Breiner and R. Karni. Energy and the Israel economy. *European journal of Operational Research* 13, 1983.

[Bridge 67]
J.H. Bridge. *Applied econometrics*. North Holland Publishing Co, Amsterdam, 1967.

[Brookes 72]
L.G. Brookes. More on the output elasticity of energy consumption. *Journal of Industrial Economics* 2(1), 1972.

[Bullard and Sebald 75]
C.W. Bullard and A.V. Sebald. A model for analyzing the energy impact of technological change. *Proceedings of the 1975 Summer Computer Simulation Conference ,* 1975.

[Cargill and Meyer 71]
T.E. Cargill and R.A. Meyer. Estimating the demand for electricity by time of day. *Applied Economics* 3, 1971.

[Caves and Christensen 79]
D.W. Caves and C.R. Christensen. *Econometric analysis of residential time-of-use electricity pricing experiments*. Workshop Paper SSRI-7824, University of Wisconsin, Social Systems Research Institute, December, 1979.

[Caves and Christensen 80]
D.C. Caves and L.R. Christensen. Residential substitution of offpeak for peak electricity usage under time of use pricing. *The Energy Journal* 1(2), 1980.

[Chang and Chern 81]
H.S. Chang and W.S. Chern. Specification, estimation and forecasts of industrial demand and price of electricity. *Energy Systems and Policy* 5(3), 1981.

[Chern and Lin 76]
W.S. Chern and W. Lin. Energy demand for space heating: An econometric analysis. In Proceedings of the Economics and Statistics Section. *American Economic Association*, 1976.

[Chern 76]
W.S. Chern. *Energy demand and interfuel substitution in the combined residential and commercial sector*. Technical Report RM-5557, Oak Ridge National Laboratory, 1976.

[Chetty 68]
V.K. Chetty. Pooling of time-series and cross-sections data. *Econometrica* 30(2), 1968.

[Christ 66]
C. Christ. *Econometric models and methods*. John Wiley & Sons, N.York, 1966.

[Cicchetti and Smith 75]
C.J. Cicchetti and V.K. Smith. Alternative price measures and the residential demand for electricity. *Regional Science and Urban Economics*, December, 1975.

[Cohn, Hirst and Jackson 77]
S. Cohn, E. Hirst and J. Jackson. *Econometric analyses of household fuel demands*. Technical Report ORNL/CON-7, Oak Ridge National Laboratory, 1977.

[Common and Peirson 79]
M. Common and J. Peirson. Environmental benefits and the economics of U.K. solar energy schemes. *Energy Economics* 1(3), July, 1979.

[CRA 76]
Charles River Associates. *Long-range forecasting properties of state-of-the-art models of demand for electric energy*. Technical Report EA-221, Electric Power Institute, 1976.

[Cramer 71]
J.S. Cramer. *Empirical econometrics*. North Holland Publishing Co, Amsterdam, 1971.

[Delis 87]
C. Delis. *Cost structure and tariff policy in the electricity field*. Institute of Economic and Industrial Research, Athens, 1987.

[Dewolff 37]
P. Dewolff. De vraag nerlover per tram. *De Nederlandse Conjunctuur*, 1937.

[Doctor and Anderson 73]
R.D. Doctor and K.P. Anderson. *California's electricity quandary: Slowing the growth rate*. Technical Report R-1116-NSF/CSA, Rand Corporation, September, 1973.

[DOE 78]
Department Of Energy. *Draft documentation report on the regional demand forecasting model*. Synergy Inc, Washington D.C., 1978.

[Donnely and Diesendorf 85]
W.A. Donnely and M. Diesendorf. Variable elasticity models for electricity demand. *The Energy Economics Journal* 7(3), July, 1985.

[Dunkerley 82]
J. Dunkerley. Estimation of energy demand: The developing countries. *The Energy Journal* 3(2), 1982.

[Dupuit 52]
J. Dupuit. On the measurement of utility if public works. *International Economic Papers* 2, 1952.

[EMF 4 81]
Energy Modeling Forum 4 working group. Aggregate elasticity of energy demand. *The Energy Journal* 2(2), 1981.

[Eurostat Review 84]
Eurostat Review. Office des Publications Officielles des Communites Europeenes. Luxemburg, 1975-1984.

[Evans 69]
M. Evans. *Macroeconomic activity: Theory, forecasting and control*. Harper and Row Publishers, N. York, 1969.

[Fase 68]
M.M. Fase. De vraag naar openbaar nernoer in de drie grote steden. *De Economist* 116, 1968.

[Feldstein 72]
M.S. Feldstein. Equity and efficiency in public sector pricing: The optimal two-part tariff. *The Quarterly Journal of Economics* 82(2), 1972.

[Fisher and Kaysen 62]
F. Fisher and C. Kaysen. *A study in econometrics: The demand for electricity in the United States*. North Holland Publishing Co, Amsterdam, 1962.

[Fox 58]
K.A. Fox. *Ames.: Econometric analysis for public policy*. Iowa State College Press, 1958.

[Garbacz 82]
C. Garbacz. Lifeline electricity rates as an income transfer device: Comment. *Land Economics* 58, 1982.

[Garbacz 83]
C. Garbacz. Electricity demand and the elasticity of the intramarginal price. *Applied Economics* 15(5), October, 1983.

[Gill and Maddala 76]
G.S. Gill and G.S. Maddala. Residential demand for electricity in the TVA area: An analysis of structural change. In *Proceedings of the Business and Economic Statistics Section*. American Economic Association, 1976.

[Gill and Tyrrell 74]
G.S. Gill and T.J. Tyrrell. Demand estimation and forecasting regional electricity demand in the context of rising electricity prices. *Proceedings of the 1974 Summer Computer Simulation Conference*, July, 1974.

[Goldberg and Gamaletsos 67]
A.S. Goldberg and T. Gamaletsos. *A cross-country comparison of consumer expenditure patterns*. University of Wisconsin: Systems Formulation, Methodology and Policy Workshop Paper 6706, Social Systems Research Institute, 1967.

[Goldberg 67]
A.S. Goldberg. *Functional form and utility: A review of the consumer demand theory*. University of Wisconsin: Systems Formulation, Methodology and Policy Workshop Paper 6703, Social Systems Research Institute, 1967.

[Griffin 74]
J.M. Griffin. The effects of higher prices on electricity consumption. *The Bell Journal of Economics and Management Science* 5(2), Autumn, 1974.

[Grilliches 67]
Z. Grilliches. Distributed lags: A survey. *Econometrica* 35(1), January, 1967.

[Grunfeld and Grilliches 60]
Y. Grunfeld and Z. Grilliches. Is aggregation necessarily bad? *The Review of Economics and Statistics* 42(1), February, 1960.

[Halvorsen 73]
R. Halvorsen. *Demand for electric power in the United States*. Discussion Paper 73-13, Institute for Economic Research, December, 1973.

[Halvorsen 75]
R. Halvorsen. Residential demand for electric energy. *The Review of Economics and Statistics* 57(1), February, 1975.

[Halvorsen 78]
R. Halvorsen. *Lexington Books: Econometric models of U.S. energy demand*. D.C.Heath & Co, Mass., 1978.

[Hemelrijk 66]
Hemelrijk. Underlining Random Variables. *Statistica Neerlandica* 20, 1966.

[Henderson 47]
A. Henderson. The pricing of public undertakings. *Manchester School* 15, 1947.

[Hewlett 77]
J.G. Hewlett. Changing patterns of households' consumption of energy commodities. In *Proceedings of the Business and Economic Statistics Section*. American Statistical Association, 1977.

[Hotelling 38]
H. Hotelling. The general welfare in relation to problems of taxation and of railway and utility rates. *Econometrica* , July, 1938.

[Houthakker and Taylor 70]
H.S. Houthakker and L.D. Taylor. *Consumer demand in the United States: Analyses and projections*. Harvard University Press, Cambridge, Mass., 1970.

[Houthakker, Verleger and Sheehan 74]
H.S. Houthakker, P.K. Verleger and D. Sheehan. Dynamic demand analyses for gasoline and residential electricity. *American Journal of Agricultural Economics* 56(2), 1974.

[Houthakker 60a]
H.S. Houthakker. Additive preferences. *Econometrica* 28(2), April, 1960.

[Houthakker 60b]
H.S. Houthakker. The influence of prices and income in household expenditure. *Bulletin of the International Statistical Institute* 38(2), 1960.

[Houthakker 65]
H.S. Houthakker. New evidence on demand elasticities. *Econometrica* 33(2), April, 1965.

[Houthakker 80]
H.S. Houthakker. Residential electricity revisited. *The Energy Journal* 1:1, 1980.

[Hsiao and Hsiao 85]
F.S.T. Hsiao and M.C.W. Hsiao. Elasticities, ratios and energy modeling. *Energy Economics* 7(3), June, 1985.

[Hsiao and Mountain 85]
C. Hsiao and D. Mountain. Estimating the short-run income elasticity of demand for electricity by using cross-sectional categorized data. *Journal of American Statistical Association* 80(39), June, 1985.

[Hudson and Jorgenson 73]
E.A. Hudson and D.W. Jorgenson. U.S. energy policy and economic growth, 1975-2000. *Bell Journal of Economics and Management Science* 5(2), Autumn, 1973.

[Humphrey and Stanislaw 79]
W.S. Humphrey and J. Stanislaw. Economic growth and energy consumption in the U.K., 1700-1975. *Energy Policy* 7(1), 1979.

[Iwayemi 81]
A. Iwayemi. An econometric analysis of the demand for electricity in Nigeria. *Research and Development* 1(1), January, 1981.

[Jones 84]
H.M. Jones. *A guide to the statistical analysis of the results of linear and non-linear least squares data fitting*. Technical Report NPL-DICT 53/84, National Physical Laboratory, December, 1984.

[Kahn 70]
A. Kahn. *The economics of regulation*. John Wiley & Sons, N.York, 1970.

[Koopmans 51]
T. Koopmans. *Activity analysis of production and allocation*. John Wiley & Sons, N. York, 1951.

[Kouris 81]
G. Kouris. Elasticities: Science or fiction?. *Energy Economics* 3(2), April, 1981.

[Kraft and Kraft 78]
S. Kraft and D.A. Kraft. On the relationship between energy and GNP. *Journal of Energy and Development* , 1978.

[Kuh 59]
E. Kuh. The validity of cross-sectionally estimated behavior in the time-series applications. *Econometrica* 27(2), 1959.

[Labys 82]
W.C. Labys. Measuring the validity and performance of energy models. *Energy Economics* 4(3), 1982.

[Lacy and Street 75]
A.W. Lacy and D.R. Street. *A single firm analysis of the residential demand for electricity*. University of Alabama, Department of Economics, Auburn, 1975.

[Lester 63]
C.E. Lester. Forms of Engel functions. *Econometrica* 31(4), 1963.

[Liviatan 63]
N. Liviatan. Consistent estimation of distributed lags. *International Economic Review* 4(1), January, 1963.

[Marshall 90]
A. Marshall. *Principles of Economics*. Macmillan, London, 1890.

[Mayer 78]
L.S. Mayer. Estimating the effects of the onset of the energy crisis on residential energy demand. *Resources and Energy* 1, 1978.

[McFadden and Puig 75]
D. McFadden and C. Puig. *An econometric model of the demand for electricity*. Economic Impact of Water Pollution Control on the Steam Electric Industry Report EED-12, Teknekron Inc, 1975.

[McFadden, Puig and Kirshner 77]
D. McFadden, C. Puig and D. Kirshner. Determinants of the long-run demand for electricity. In *Proceedings of the Business and Economic Statistics Section*. American Statistical Association, 1977.

[Moore 14]
H.L. Moore. *Economic cycles: Their law and cause*. Macmillan, N.York, 1914.

[Moore 70]
T.G. Moore. The effectiveness of regulation of electric utility prices. *Southern Economic Journal* 36(4), 1970.

[Mount, Chapman and Tyrrell 73]
T.D. Mount, L.D. Chapman and T.J. Tyrrell. *Electricity demand in the United States: An econometric analysis*. Technical Report ORNL-NSF-EP-49, Oak Ridge National Laboratory, 1973.

[Nordin 76]
J.A. Nordin. A proposed modification of Taylor's demand analysis: Comment. *Bell Journal of Economics*, 1976.

[Pace 75]
J.D. Pace. The poor, the elderly and the rising cost of energy. *Public Utilities Fortnightly* 95(12), 1975.

[Parti and Parti 80]
M. Parti and C. Parti. The total and appliance specific conditional demand for electricity in the household sector. *The Bell Journal of Economics* 11, 1980.

[Rigas 82]
C.A. Rigas. *The demand for alternative kinds of energy in the Greek economy: An econometric analysis*. PhD thesis, Piraeus School of Industrial Studies, 1982.

[Roth 76]
W.E. Roth. Micro-data measurement of residential rate restructuring. *Public Utilities Fortnightly* 15, January, 1976.

[Ruggles 50]
N. Ruggles. Recent developments in the theory of marginal cost pricing. *Review of Economic Studies* 17, 1950.

[Samuelson 52]
P.A. Samuelson. Spatial price equilibrium and linear programming. *American Economic Review* 42, June, 1952.

[Samuelson 57]
P.A. Samuelson. Intertemporal price equilibrium: A prologue to the theory of speculation. *Weltwirtscaftliches Archiv* 79, 1957.

[Scherer 70]
F.M. Scherer. *Industrial market structure and economic performance*. Rand McNally h Co, Chicago, 1970.

[Schultz 38]
H. Schultz. *The theory and measurement of demand*. University of Chicago Press, Chicago, 1938.

[Smil and Kuz 76]
V. Smil and T. Kuz. European energy elasticities. *Energy Policy* 4(2), 1976.

[Smith 80]
V.K. Smith. Estimating the price elasticity of U.S. electricity demand. *Energy Economics* 2(2), April, 1980.

[Starr 78]
C. Starr. *Energy use: An interregional analysis with implications for international comparisons*. Consumption Research Paper R-10, Resources for the Future, 1978.

[Statistical Yearbook 85]
The Statistical Yearbook of Greece. Hellenic Statistical Association. Athens, 1976-1985.

[Suits 57]
D.B. Suits. Use of dummy variables in regression equations. *The Journal of the American Statistical Association* 52, December, 1957.

[Takayama and Judge 64a]
T. Takayama and G.G. Judge. Equilibrium among spatially separated markets: A reformulation. *Econometrica* 32(4), October, 1964.

[Takayama and Judge 64b]
T. Takayama and G.G. Judge. An intertemporal price equilibrium model. *Journal of Farm Economics* 18(2), May, 1964.

[Takayama and Woodland 70]
T. Takayama and A.D. Woodland. Equivalence of price and quantity formulations of spatial equilibrium: Purified duality in quadratic and concave programming. *Econometrica* 38(6), November, 1970.

[Taylor, Blattenberger and Verleger 77]
L.D. Taylor, G.R. Blattenberger and P.K. Verleger. *The residential demand for energy (vol 1)*. Technical Report EA-235, Electric Power Research Institute, 1977.

[Taylor 75]
L.D. Taylor. The demand for electricity: A survey. *The Bell Journal of Economics* 6, 1975.

[Terza and Welch 82]
J.V. Terza and W.P. Welch. Estimating demand under block rates: Electricity and water. *Land Economics* 58(2), May, 1982.

[Terza 86]
J.V. Terza. Determinants of household electricity demand: A two-stage probit approach. *Southern Economic Journal* 52, April, 1986.

[Theil 57]
H. Theil. Specification errors and the estimation of economic relationships. *Review of the International Statistical Institute* 25(1/3), January, 1957.

[Thomas 85]
R.L. Thomas. *Introductory econometrics: Theory and applications*. Longman Grcup Ltd, N.York, 1985.

[Ubogn 85]
R.E. Ubogn. Demand for electricity in Nigeria: Some empirical findings. *Socio-Economic Planning Studies* 19(5), 1985.

[Uri 75]
N.D. Uri. *Lexington Books: Towards an efficient allocation of electrical energy*. D.C. Heath & Co, U.S., 1975.

[Uri 76]
N.D. Uri. Short-run variations in the demand for electric energy. In *Proceedings of the Business and Economic Statistics Section*. American Economic Association, 1976.

[Uri 78]
N.D. Uri. The demand for electric energy in the United States. *Energy Systems and Policy* 2(2), 1978.

[Uri 80]
N.D. Uri. Price expectations and the demand for electric energy. *Energy Systems and Policy* 3, 1980.

[Voloudakis and Panourgias 86]
E. Voloudakis and E. Panourgias. *The regional distribution of national income in 1981: Intertemporal changes and inter temporal comparisons (1961-1981)*. Economic Research Department, Bank of Greece, 1986.

[Walker 79]
J.M. Walker. The residential demand for electricity: Further empirical evidence. *Resources and Energy* 2, 1979.

[Westoby and McGuire 84]
R. Westoby and A. McGuire. Factor substitution and complementarity in energy: A case study of the U.K. electricity industry. *Applied Economics* 16, 1984.

[Wilcox 71]
C. Wilcox. *Public policies towards business*. Richard D.Irvin, Homewood 111, 1971.

[Wilder and Willenborg 75]
R.P. Wilder and J.F. Willenborg. Residential demand for electricity: A consumer panel approach. *Southern Economic Journal* 42(2), October, 1975.

[Wills 77]
J. Wills. *Residential demand for electricity in Massachusetts*. Working Paper MIT-EL-77-016WP, Massachusetts Institute of Technology, 1977.

[Wilson 71]
J.H. Wilson. Residential demand for electricity. *The Quarterly Review of Economics and Business* 11(1), 1971.

[Working 27]
E.J. Working. What do statistical "demand curves" show? *The Quarterly Review of Economics* 41(9), May, 1927.

[Zellner 62]
A. Zellner. An efficient method of estimating seemingly unrelated regressions and tests for aggregation bias. *Journal of the American Statistical Association* 57, June, 1962.

[Zilberfarb and Adams 81]
B.Z. Zilberfarb and F.G. Adams. The energy-GDP relationship in developing countries: Empirical evidence and stability. *Energy Economics* 3(4), October, 1981.

THE BENEFACTION AND PATRIOTISM OF WESTERN MACEDONIA'S FUR MAKERS IN THE COURSE OF CENTURIES AS A PRECURSOR OF C.S.R.

***Leonidas Pouliopoulos*[*], *Anastasios Ntanos*[**], *Theophilos Pouliopoulos*[***]**

Abstract

Kastoria and Siatista two of the most historical regions of Western Macedonia with rich cultural, commercial and craft-based activity, are the only regions in Europe that managed to survive the whirlwind of globalisation and still maintain fur manufacturing alive even though significantly smaller. Based on the facts that we have available up to date, fur manufacture and trade in these regions are dated from the 15th century, and both activities have brought forth many achieved tradesmen with rich offer as benefactors and sponsors not only in their mother country, but also in their places of residence. Of course back then the term corporate social responsibility was unknown but the love for ones country, patriotism, benefaction, and any other act of social contribution and pure patriotism, were itself another form of expression, that resembled more that of "the social corporate responsibility" instead of the corporate social responsibility. These therefore, the economic, social and charitable acts of people from another time we will be discussing in order to prove that, the current activities of enterprises on environmental issues, social sensitivity, culture, training etc, did not emerge out of nowhere, but in reality pre-existed

* Assistant Professor, TEI of Western Macedonia, Kastoria, Greece, pouliopoulos@kastoria.teikoz.gr
** PhD, Associate professor TEI Piraeus, Greece, antanos@yahoo.gr
*** (MBA), theopouliopoulos@yahoo.gr

from the older years. They were simply presented and characterized differently, as different were the needs of each time. Beyond this however, we will also be referring on the necessity for the craft-based sector of fur manufacturing, to organise a network in order to both continue with the tradition of their predecessors and also further develop this value adding activity as much for the whole industry but also for the end-product itself.

Keywords: Economic crises, ecological sensibility, donors, benefits
JEL Classification: N 90

1. Kastoria and Fur History

Kastoria and Siatista are two of the few remaining regions, not only in Greece, but also in the entire Europe where the processing of fur and skin is still alive. As it is reported in the "*DICTIONARY of FUR*" Kastoria who is the capital of the prefecture of Kastoria, is also the most beautiful furmaking city in the world. The history of furs and leather treatment technique seems to have started when some citizens from Kastoria transferred the related know-how from Constantinople (Istanbul) during the 15th century. The broader region around the lake is inhabited since 5.500 B.C., but the foundation of Kastoria itself is dated in 840 B.C. Although the art of furs and leather treatment may have started with imported knowledge from Istanbul, the specialized treatment of furs clippings, like legs, heads and tails is a technique developed especially in the region by the Kastorian craftsmen. (Pouliopoulos L. & Sionta V., 2005, pp. 31)

2. The Economic Crises in the Fur Trade

Historically it has been proven that, there were economic crises in the sector of fur from the older years. Such crises emerge from various reasons and factors, such as new discoveries, changing fashion trends, wars, social agitations, international competition, production surplus, ecological movements, hot winters etc. The first crisis was reported already in the Neolithic era, where men learned to cultivate, raise animals, etc. As a result, both the linen and wool dominated and the costume of fur-making went into recession.

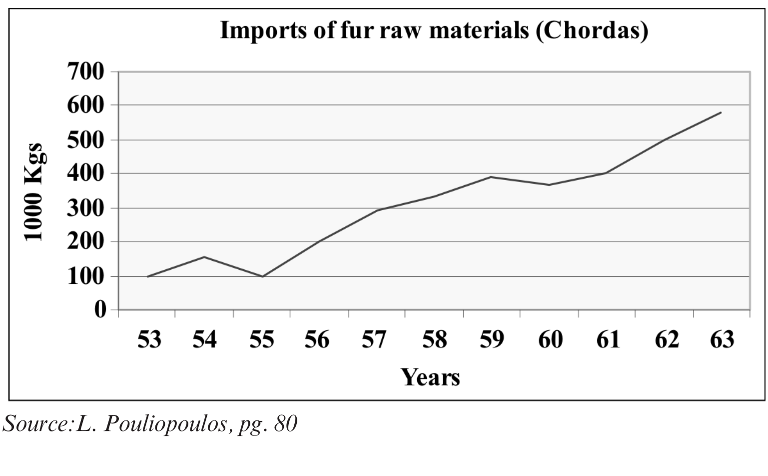
For another crisis that is owed in the change of fashion, we are informed by Skarlatos Byzantios between 1825 and 1850. (Akilas, M., (1996), σελ. 586)

After that, a ''blossom'' in the economy can explain the heavy construction of many mansions between 1860-1880, followed by a period of decline and the immigration of kastorians in northern America and mainly in N. Yorκ. Another crisis followed the fall of the Ottoman Empire, during the First World War and the Asia Minor destruction, which influenced the manufactures of Thessalonica, Giannena, Filippoupoli, Andrianoupoli, Chios, Kozani etc because they did not have commercial relations with countries outside of the Ottoman sovereignty, unlike Kastoria and Siatista. (Pouliopoulos, L., (1994) pp. 58)

Other economic crises, called circular were present in the decade of 1960s. At the decade of '50s because of the reconstruction of Western Europe and more generally the western world following the 2nd World War there was a rapid growth without important fluctuations as it is shown in fig. No 1. During the 60's however, we have two important fluctuations, in 1963 and in 1967 and one smaller in 1970, as it is shown in fig. No 2.

These figures show imports of raw material of furs the corresponding periods, which coincides with the circular fluctuations of the economic crises in the western societies of this time.

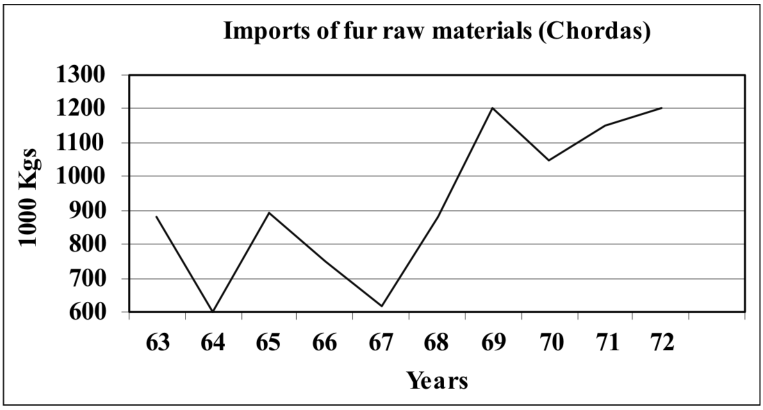
Figure 1: Imports of raw material (Chordas) from 1952 to 1963 in Kastoria. (in 1.000 Kg)



Source:L. Pouliopoulos, pg. 80

A big extended crisis existed after 1987 up to 1992 roughly, which for Kastoria and Siatista, was overcome provisionally with the opening of the market of the Eastern countries and mainly Russia. Another big crisis

Figure 2: Imports of raw material from 1963 to 1972 in 1.000 Kg.



Source: Spanos M. (Kastorian CCI) L. Pouliopoulos, p. 81

that influenced fur-making was in 1998, with the depreciation of rouble in Russia, which was overcome much faster compared to that of 1987. Another crisis was observed (in Greece) in 2006-7, where the sales declined because of the high temperatures during that winter and the prices of fur skins were found for a little time in a free fall, mainly in the auctions of winter and the beginning of spring. Afterwards the prices of fur skins (raw material) began to increase dramatically alongside oil prices, because of the big demand from Chinese businessmen. As fur itself is considered to be a luxury product (at least in countries that do not have heavy winters), it was inevitably affected by the big financial crisis of 2008. This financial crisis that began from the USA, was already present earlier in 2007 through the minor originally "falls" of Stock Exchange indicators which climaxed on 18/10/2008, when we had not only the rapid fall of all Stock Exchange indicators, but also the collapse of banks and other companies.

Naturally during this crisis the fur industry was highly affected despite the fact that its major consumer is no longer the USA and Western Europe but rather Russia. The first reaction from consumers was to cancel all orders and from the suppliers to admit liability in financing their obligations. All of the above forced a lot of enterprises to reduced production and personnel downsizing.

3. Corporate Social Responsibility

The corporate social responsibility is substantially a means by which the companies decide willingly to contribute for a better society and a cleaner environment. Most definitions describe the CSR as a means according to which the companies incorporate voluntarily, social and environmental concerns in their enterprising activities and their contacts with other interested parts.

The Greek Network for the CSR reports that, it is the willing engagement of the enterprises to integrate in their enterprising practices social and environmental actions, that are beyond and above those imposed by the legislation and have direct relation with all parties influenced by them: workers - shareholders - collaborators - suppliers - investors - consumers - communities in which they activate and more.

The CSR Europe, the network for the CSR in Europe reports that the CSR refers to the way by which an enterprise manages and improves its social and environmental repercussions, so that it adds value as much in the shareholders, and to all interested parties, through strategic, organizational and operational innovations. (Europäische Kommission (2002a), (KOM 2002, 347).

The world council on the sustainable growth reports: CSR is the commitment of enterprises to contribute in the viable growth via the collaboration with their personnel, the local societies and the society in general so that they improve the quality of life for everybody.

The last decades mainly in the developed countries, the interest for the social and ecological obligations of enterprises has increased; a fact that is owed partly in the action of ecological movements and organisations of consumers and to the requirements generated by our socio-political system itself. The allegations that the enterprises should allocate a part of their economic resources in activities of social content have not always been easily accepted. The writers that dealt with the particular subject disagreed, as per the ability or the purpose of the companies dealing with any social act or if that should be an obligation only of the state.

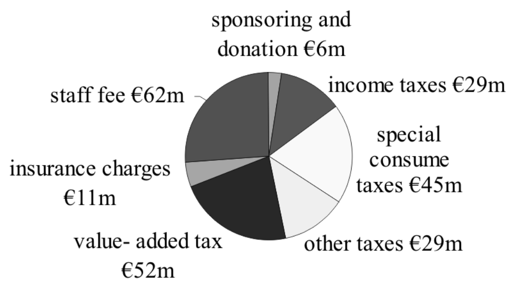
This conflict had lasted a lot of years and it has been crystallized in the work and in the thoughts of two important writers, honoured with reward Nobel Milton Friedman and professor of University of Arizona Keith Davis, who separated the CSR in three levels, i.e. that of social obligation, of social responsibility and of the social response. In this point we clarify that, various statistical tables that are published in various newspapers or other forms as the one that we mention below, concern first degree SR that is the social obligation. Therefore, the whole dimension of CSR is not considered complete but even is partial execution or operation, is a first step for a future complete application. (Montana, P., Charnov B. 2002, pp. 64)

In the following figure No 3, we can see a distribution of resources and activities of a medium big enterprise, mainly in this first degree of social responsibility that is characterized as social obligation. This degree of course cannot be included entirely in what is called CSR because in the bigger part it includes operations or obligations that are not voluntary but obligatory as egg the yields in direct and indirect taxes etc What however we observe is that the action of social responsibility amount in the sum of € 6 millions , which is big, if it is really used only in voluntary hence not obligatory action S.R.

Figure 3: Informative type of a company related to the CSR

The contribiution of corpoprate action in the greek society and economy

a. 1.217. Employers
b. €24.600.000 investments
c. exports in 27 countries
d. 34.622 people depending on our corporate activity
e. €155.409.000 taxes
f. €6.000.000 on social responsibility actions



In order for someone to imagine how much the perception, the mentality or the psychology of our society ha changed toward the subject of SR. I will report an example from the Greek reality. When singer Markos Vamvakaris died in 1972, his family was borrowed 30 thousands drachmas (then 1.000 dollars USA), in order to cope with the expenses of his funeral, expressing her disappointment for the indifference of the state and the private sector. Today of course many companies of the entertainment industry line-up in order to undertake such an obligation of even much bigger scope.

The average distrustful citizen today, would say that, they make these (the social work) the enterprises, so that they gain more either because of tax exemptions, or for certain other reasons. But is it so, or could this be an exaggeration? Of course a lot of researching has been made in this direction and today we know a lot of things, about what the citizens know, or which opinion they have for the CSR and a lot of other facts.

In other countries that have great tradition in the social state another question arises. If that is to say instead of corporate social responsibility, should we speak perhaps of social corporate responsibility. (GUV) (Gesellschaftliche Unternehmensverantwortung). We here cannot enter in such details but only underline and stress that, the CSR as an operation in an enterprise is essential, socially imposed, it creates surplus value in the enterprise and alas in those enterprises, that will see and face it as a public relation element, in order to generate only short-term profits. (Bernhard U. a.a., 2008, pp. 15)

All researches and the studies have proved that, if CSR is dialled with as an act of social responsibility, in the mission and in the strategic planning of an enterprise, then so much the shareholders and the entire society, including also consumers, will appreciate and reward with their trust and their preference in the products or their services. Moreover is not accidental that big enterprises in Greece, not only adopted CSR, but also advertise it via the press. As an example I report one from the thousands cases, a company of mobile telephony, which committed, for each point of the basketball player and our fellow-citizen Dimitri Diamantidi, to attribute 100 Euros in the Prefectoral Association of People with special needs of Kastoria.

4. The CSR in the Branch of Fur

Questions that should be answered here are the following: Can this operation be used in the branch of fur? Are the enterprises of fur so big and robust to invest in an activity where the profits won't be immediately visible? The answer is of course YES, because CSR it can be included in each enterprise, depending on the size and can begin from the simple sponsoring and the organisation of athletic events, up to the training, the prevention, the education and a pile other environmental and social activities. However as mentioning before, can the enterprises of fur function under one institution, or one existing, as the already existing network CSR or create a new institution or even the already existing institutions as the SGK (Furmaker Association) assuming they include in their statement of mission, the CSR as strategic henceforth planning in their objectives. The CSR in the branch of fur should be applied for all reasons that are in effect for the other enterprises plus one additional, that we will explain afterwards.

4.1 Greek benefaction

The sponsorships, the benefactions, the charities and other actions of social sensitivity, are not a modern phenomenon. In Greece the institution of sponsoring, benefaction and other social actions in favour of the society are known from the ancient years. The Olympic Games that were carried out in Greece by 8th century B.C. were organised with the help of sponsors. Consequently CSR as we know it in its current form, passed a lot of stages of development, in order to reach thus its present state today.

Greek benefaction constitutes a phenomenon with a particular place in the Modern Greek history. The operation of benefactors was historically progressive and decisive, for the constitution of government owned institutions and the predominance of the amounting working class. In the new conditions that imposed the social transformation, the benefactors undertake, via the big fortune that they had, social undertakings with terms of individual work. From this corner, the idea of benefaction represents a leading event social, national and cross-cultural conscience, which by bypassing in many cases the weakness of the government concern, proved the strategic supremacy of anthropocentric dimension of social life.

The difficult economic, political, demographic and living conditions as well as the big pressure from the Turkish conquerors led the Greeks at the last quarter of the 17th, 18th and to the beginning of 19th century to emigrations. The hope for a better life abroad, the trade and the thirst for learning were the more important reasons of immigrations. The trade constituted the most important factor in the foundation of new Greek communities. The growth of economic relations between east and west offered the possibility to the Macedonians, Epirotes and remaining Greeks of migrating and with their hard work to acquire big fortunes.

The regions that assembled a lot of Greeks were mainly central Europe, northern Balkan and Russia. (Milonas D. (2009), σελ. 25)

Is characteristic the report of Emil Brass in a book of 1925 where he is reporting the activity of Greek fur traders in Leipzig at the 18th and 19th century and among many he writes the following:

> ... as long as it concerns Germany, the center of fur that time, was Leipzig. Certainly Greeks were not absent from there not to mention the western Macedonians, kastorians etc, who with their graphic costumes revived the streets of Leipzig mainly at the duration of the Fur Fair, since from the total 300 tradesmen, the 100 were Greeks. (Brass E., 1925, pp. 286)

The Greek emigrants, despite the unfavourable conditions acquired big economic surface and power and thus they could help their countries which were under the Turkish domination and benefit their homeland, as Nikolaos Doumpas from Vlasti, who was born in Vienna and rescued from the dissemination the bigger part of Franz Schubert compositions and gave them away to the Municipality of Vienna.

Equally decisive was his contribution, in the materialisation of the magnificent hall of "Friends of Music", the famous "Musikverein". For all this the Municipality of Vienna gave in this street his name, Dumbastrasse. He was close friend of Richard Wagner, Jochan Strauss, and Jochanes Brahms. He played a leading part in the construction of statues of big personalities of Vienna (Beethoven, Rantetski, Mozart, Schubert, Siler and Brams). His contribution in building construction was also major in Vienna but also in Athens.

The economic activity of benefactors was a common phenomenon in the Greek and more generally in European reality, because it was part of a new urban class, which gave them power and "wealth" of new perceptions, which they brought with them when they returned to their mother country together with, revolutionary ideas and wealth.

4.2 The social sensitivity of fur traders of Western Macedonia

In the sector of fur there were, still are and will continue to be too many entrepreneurs and companies, who made great social work as benefactors, which undoubtedly falls within the CSR.

Manolakis the Kastorian or Manolakis George Manos, referred to the

Dictionary of Fur as a fur merchant and supplier to the palace of Mehmet D in 17th century. He had the title of "the first furmaker" and spent huge sums for the rebirth of the Greek nation. The Co-op of the fur makers of Constantinople which Manolakis attended on 19th century maintained the great school of the nation otherwise known as traditional patriarchal academy. Manolakis and The Co-op of fur in Istanbul finance and undertake the payroll of the Holy School in Kastoria in 1715. Manolakis financed the construction of the famous school of Patmos, the school of Victor in Chios (1660) and the School of Arta (1669). Also under the protection of fur Co-op was the school of district (Constantinople) of Palinou .Moreover it is no coincidence that the Co-op (trade union) of furs mentioned even today in the Patriarchate of Constantinople. (Makris, Haris, (2000) pp. 69-70)

Other benefactors of that time were acknowledged kastorians Kastriotis George and Kyritsis George. Kastriotis (who is not related to the famous George Kastriotis or Skentermpei) in 1705 as the official ruler of Constantine Oungrovlachias Basarampa Bragkovanou, founded a school in Kastoria, for the maintenance of which he made a money deposit in Venetian Tsekos. A few years after the founding of the school of Kastriotis, another wealthy kastorian merchant named Kyritsis., son of kastorian Lord Demetrius Kyritsis reinforced the economic foundation of the "Greek School", realising therefore the decision taken by the kastorians on August 1711. This school was to be maintained by interest funds, he had deposited in Venice and would be managed by the Christians of his homeland. (Koutsiaftis, Emanouil, (2001) pp. 54, 64)

It is important to mention here that the donor or benefactor dictated details and procedures for choosing the Commissioners who will be collecting the interest from Venice and how the will, will be managed. Of the 225 Duke of annual interest, the teacher will be paid at 150 per year to teach 24 students and reward the best of them "to the best in mind and knowledge", with the sum of 18 silver Duke each year for 7 years. The remaining balances of interest ordered to be used to repair the building and for any emergency. The last clause of this will dictates, as case kastorians show any disrespect, school must remain closed for two years and interest on deposits is to be received by the clergy of the church St. Athanasius Mitropoleos in Ioannina... For the school and the teachers of the city: January 15, 1715.

Of course beyond the known and officially recorded beneficence, sponsorships, etc. there were many other acts of social sensitivity that had more relationship with the homeland and the nation because times were different back then and acts of solidarity of social sensitivity and responsibility were focused on the homeland and the fellow citizens of the benefactor. We can not know all the hidden and informal perhaps patriotic acts, of national and social responsibility and sensitivity, because of the Ottoman sovereignty. But we are mentioning one of them, which is the case of furtrader Kostaki Pouliopoulos, who during the Macedonian Struggle (1900-1912) he would hide boots and other articles intended for the needs of Macedonian fighters, in parcels of raw material fur (strings), which were sent from London in Kastoria.

Naturally back then, beneficence was done more for patriotic or national reasons but it was of significance as, some things were tolerated by the Ottomans and considered legal or acceptable, but there were acts which could be misunderstood by them and endanger the benefactor. So, there were acts of social sensitivity, which could endanger the "donor", to the point of having to pay with his own life.

This means that a moral act may not have been legitimate and could jeopardize the "donor-benefit" which means that social sensitivity and social responsibility in different conditions and seasons had a different meaning and value than in the current time which may involve communicative or other purposes. But it must be stressed that CSR was existing since ancient times, was just under different circumstances and ways because there were different needs on each era.

Today of course there are too many donors and benefactors of small and large scale known and unknown named and anonymous. Among many and varied acts and actions of social responsibility and sensitivity we can distinguish that one of the brothers Papageorgiou from Siatista (the second fur-city after Kastoria in Greece). The international standing and reputation furtraders from western Macedonia, who trade mainly active in Germany and manufactured in their hometown Siatista, winning a lot of money from this activity, that all furmen inherited from their ancestors, built the Papageorgiou Hospital in Thessaloniki, engaging 20 years ago the amount of 6 billion drachmas, or 18 million euro.

5. Practical Applications

The implementation of CSR can be done at many levels. The most usual of course is sponsorship which does not require any organizational structure. Another act that could happen is the non-use of printed advertising material, together with clear communication on how many trees are saved and do not harm the environment. Another very important activity that creates high added value of social capital for an institution or company, is organizing sports events, attracting sponsors and co, as local sports organisations, etc.

The areas in which a body such as S.G.K. could then be engaged in are:

- Mere occasional or permanent sponsorship.
- Organized sports tournaments and other events.
- Reduced papers for no charge and protect the environment.
- Cooperation with NGOs for adoption or other charitable acts.
- Additional environmental and social activities.
- Commitment that a percentage of the selling price of a product will be attributed to vulnerable groups, etc.

5.1 The reasons for the acceptance and operation of the CSR

The reason for which CSR is essential to the operations of the fur industry is the same as those applied to other industries or other industrial or craft or service. But there is an additional reason why the industry should implement CSR which of course we will explain. We all know that the fur industry for many years has received many reactions or even from various environmental organizations, which do not accept the fur of animals, whose skin is used for the clothing of humans. Many enterprises from the sector in the past and present , used and use the squirrel or beaver as a mark of their business as if companies had fur animals. Fortunately, some companies understood it even later and they don't use them as their mark anymore.

Craft fur should separate their activities from the farmers of fur animals, because they are not farmers, and secondly because it does not coincide with the farmers. There are currently too many furmakers dedicated to leather goods, which means that their products come from animals raised for food while their skin is used for clothing. This raises a question. Perhaps the industry should be classified as a processing industry furskin and then left only of the skins to separate themselves entirely from the fur skins, which are primarily kept for their fur, not for their meat? This as a reflection and not as position.

Of course as far as the fur of animals and the killing, the circumstances and the methods used have no relation to the past, since the law was very strict and the countries that are suppliers, are a role model in ecological sensitivity and they are civilized people, who have nothing to do with a few isolated incidents that everybody publicly condemn. So then why should the industry show more social and ecological sensitivity, through the adoption of CSR, there should be neither communicative reasons nor reasons of guilt. Instead it should be a holistic approach to life and the environment and through this activity to show that although an unfortunate fact led us to exercise a profession considered by some today anti-ecologic, the furmen not adhere it but show their perception in corporate and environmental responsibility to offer and to inform the world, both for the truth about their partners or participating, and their philosophy towards life and the ecosystem. So taking the function of social corporate responsibility and not just CSR will be consolidated and will be realized as a different vision for the sector, which will not be as vulnerable to the opponents of the industry since social and ecological sensitivities of the furmen will be such that at least mitigate the reactions of most of the people.

5.2 Implications and future developments

It is true that CSR today is a function which evolves increasingly and it is being adopted by most enterprises, while the EU has established rules, directives, declarations, etc. (egg Green Paper). Also they have created networks of CSR mainly from large companies in most countries in Europe and discussions both in business and academic level converge to provide a more organized and systematic implementation of CSR. What does this mean? It means that in schools and universities there should be a new direction, perhaps comparable to T.Q.M. or even marketing, but which can create value for each entity. How to create this value depends on many factors, both internal and external.

But it is important for businesses and society, not only for the company to be accepted, because of CSR, by the society, and therefore consumers, but that there could be institutionalized rules for assessing CSR, on which companies would receive favourable financing arrangements, etc.

What then can be the benefits that can accrue to the company in the future if the EU accepts some statutory incentives? Some of these could be:

- Incentives to implement a CSR system (egg. as happened with the ISO).
- Assessment of the CSR for financing.
- Incentives in any type of organizations of middle size companies that promote and implement CSR in accordance with a framework of principles and rules.

Other benefits of a voluntary and non-institutionalized CSR could also be the following:

- Improved market value and reputation.
- Positive image in its relations with key stakeholders and others.
- Positive image to all investors and relations with trust with the shareholders.
- Possible inclusion in specific securities and banking assessment indices.
- Great visibility in society and sustainable development.
- Better working conditions.
- Employee satisfaction, willingness to work for this company.
- Good relations with government and local communities.

In addition, risks hamper CSR strengthen the company and certainly contribute to profitability. In particular:

- Infringement and trademark reputation.
- The loss of consumers.
- The probability of the firm to lose opportunities.
- The loss of staff.
- The loss of investors and funds.
- Involvement in court cases and legal problems.

The existence of foreign stock indices like the (FTSE 4 Good) in Britain (Domini 400) in America and many funds in Europe and America support the belief that CSR and financial performance go hand in hand.

Beyond the general benefits that apply for each firm specifically in the fur industry the operation of CSR can be useful in the following possible approaches.

– Community support to a cottage industry threatened by extinction
– Engaging into the craft of leather goods under certain social historical and geographical circumstances.
– The region of Western Macedonia, the last production center in Europe.
– A tradition of 500 years created by knowledge and skills that constitute social capital for local residents.
– Linking crafts - industry by using knowledge of the academic community will enhance the product and the availability and visibility.

6. Conclusions and Recommendations

In conclusion, as many companies seek to be competitive and profitable in the long term, they should include in their strategy practices of CSR, not only for the company but also for man and society, and as it is an activity affecting everyone. Summarizing we note that CSR:

– Offers Opportunities.
– Restrain threats.
– Is linked to the profitability of the company.
– Opens new horizons and prospects for the institution or enterprise.

But the question for our case is, whether the fur companies and organizations, can implement and in what extent, CSR. The answer is that they can but not to the extent of a large enterprise. But what can be done with success, is to create a network of CSR, which will express the whole industry, both firms and institutions. The proposal is for the stakeholders to proceed in the creation of an independent network of CSR to have as many as possible operators to participate for the reasons mentioned above.

References

1. Akilas, Millas, (1996) Seals of Constantinople, Εκδόσεις Συλλόγου Ιστορικής και Λαογραφικής Έρευνας, "Η Μνημοσύνη".
2. Bernhard Ungericht, Thomas Korenjak, Dirk Raith,(2008) "Corporate Social Responsibility oder gesellschaftliche Unternehmensverantwortung", ELIT VERLAG GmbH, WIEN.

3. Brass Emil, "Aus dem Reiche der Pelze" Verlag ? 'Neue Pelzwaren-Zeitung und Kürschner-Zeitung' Berlin 1925.
4. Europäische Kommission (2002a), Mitteilung der Kommission betreffend die soziale Verantwortung der Unternehmen: ein Unternehmensbeitrag zur nachhaltigen Entwicklung. (KOM 2002, 347).
5. Montana, P., Charnov B., "Management", klidarithmos publicities Athens 2002.
6. Koutsiaftis, Emanouil, (2001) "Greek education in Kastoria the 19th century", Iera Mitropolis Kastorias publicities, Thessaloniki
7. Makris, Haris,(2000) "Kastoria, short history of city", afoi Kyriakidoi publicities, Thessaloniki
8. Milonas D. (2009) "Greek sponsoring", "Pili Anaptiksis" monthly review of Western Macedonia, [10] January
9. Pouliopoulos, Leonidas, (1994) "Historical development of fur and the role of Kastoria", kastoriani estia publicities, Kastoria.
10. Pouliopoulos L. & Sionta Venetia, (2005) "Dictionary of fur", ION publicities, Athens

A REVIEW ON THEORY AND MEASUREMENT OF PRODUCTIVITY

Dr. Stylianos Drakopoulos*

Abstract

Productivity is a relationship between production and the means of production. Or, more formally a relation of proportionality between the output of a good or service and inputs which are used to generate that output. This relationship is articulated through the given technology of production. This paper investigates the relationship between productivity and technological change.

Keywords: Technical change, productivity, catching-up, economic growth.

1. Introduction

Technological progress has become virtually synonymous with long-term economic growth. This raises a basic question about the capacity of both industrial and newly industrialised countries to translate their seemingly greater technological capacity into productivity and economic growth. Usually, there are difficulties in estimating the relation between technology change and productivity. Technological change may have accelerated, but in some cases there is a failure to capture the effects of recent techno-

* Correspondence Address: Assistant Professor Dr. Stylianos Drakopoulos, Technological Educational Institute (TEI) Kalamatas, School of Economics and Business Administration, Department of Financial Economics, Kalamata, Greece.

logical advances in productivity growth or a failure to account for quality changes in previously introduced technologies. The countries of Europe have a long cultural and scientific tradition and the major scientific discoveries and developments in technology are products of European civilisation. There is a close relationship between innovation and productivity levels. However there are large technological disparities between the member states, which affects productivity performance, increases economic disparities and hinders economic integration. There are various explanations in the literature for the slow-down in productivity growth in the OECD countries. One source of the slow-down may be substantial changes in the industrial composition of output, employment, capital accumulation and resource utilisation. Another may be that technological opportunities have declined; or else new technologies have been developed but their application to production has been less successful. Technological factors act in a long-term way and should not be expected to explain medium-term variations in the growth of GDP and productivity.

This paper attempts to measure the relationship between technology and productivity, or more precisely, to investigate the correlation between technological development and the decline in productivity growth.

2. The Theory of Productivity and Technical Change

Productivity growth is crucially affected by technological change. Their relationship is so close that the two terms are often used interchangeably. Productivity is a wider concept. Even though a crucial one, technological change is only one of the many factors which affect productivity growth. Other being social, cultural, educational, organisational and managerial factors. Better management of workers and machines and appropriate incentive structures can increase production and/or reduce costs. But these are different from technological change.

It is not easy or straightforward to disentangle the effects of technological change from social and cultural factors. One simple way to conceptualise the differences is in the following way suggested by Spence (1984). If changes concern primarily people then they may reasonably be considered as being *social* in nature. On the other hand, if they appear to be fundamentally about material products and related processes then they can be more easily viewed as *technological*.

There is no simple answer to this question. Marjit and Singh (1992) have explored various aspects of this question. We confine ourselves to one directly relevant for our study. In the standard neo-classical economic model technology refers to a collection of techniques, or ways of specifying how much of various outputs can be produced using given quantities of various inputs. In most textbook situations this is simplified as a single output production function which specifies the maximum quantity of output predicable from given quantities of labour and capital. Technology is then the production function. It is generally represented graphically with the help of level curves or isoquants. Technological progress in this simple framework is a shift upwards of the production function, or shift downwards of the representative isoquant. An alternative way is to look at cost functions which relate levels of cost of production to level of output and to factor prices. In many situations cost functions are easier to characterise production functions. The data for cost functions is more easily available.

Given input prices, one can view technological improvement as a downward shift of the cost function. Technology has two aspects, 'embodied' or 'disembodied'. The former is identified with 'hardware' and consists of tools, machinery, equipment and vehicles, which together make up the category of capital goods. Disembodied technology is identified with 'software' and encompasses the knowledge and skills required for the use, maintenance, repairs, production, adaptation and innovation of capital goods. These are often called the 'know-how and the know-why of processes and products'.

Technological change does not affect all factors equally. When it does, it is considered neutral technical change. Otherwise, it may have a specific factor using or factor saving bias. The terms technological change and technical change are used interchangeably in the literature under review, both being indicators of a shift in the production function. It would have been useful to reserve the latter term for indicating change in techniques or processes. The terms technological progress and technical progress are synonymous with technological change and technical change respectively, all change being considered as being for the better (Korres, 2009).

3. Reviewing the Measurement of Productivity

There are many different approaches to the measurement of productivity. The calculation and interpretation of the different measures are not straightforward, particularly for international comparisons. Most productivity measures are procyclical; they tend to accelerate during periods of economic expansion and decelerate during periods of recession. This is partly due to measurement: variations in volume output tend to be relatively accurately reflected in economic statistics, but variations in the rate of utilisation of inputs are at best only partially picked up. Even if capacity utilisation is accurately measured, the standard model of productivity fits the realities of the business cycle somewhat awkwardly. Much economic and index number theory relies on long-term, equilibrium relationships involving few unforeseen events for economic actors.

The economic model of productivity measurement is therefore easier to implement and interpret during periods of continued and moderate expansion than during a rapidly changing business cycle. It is therefore appropriate to examine productivity growth over longer periods of time or to adjust productivity estimates for cyclical fluctuations. Whereas, the capital productivity is the ratio of output to capital and the labor productivity is the output per employed person.

The notion of a production function is central to the meaning of technology. It is consequently crucial for the measurement of productivity. A production function is a technological relationship which specifies the maximum level of output of a good which can be obtained from a given level of one or several inputs. In its general form a two input production function can be written as

$$V_t = f(K_t, L_t) \tag{1}$$

where:
V_t = level of net output (value added).
K_t = capital input (or service of factor capital)
L_t = labour input
t = time

There are three principal approaches to measurement of productivity growth. These are:

- (i) The index number approach,
- (ii) parametric approach and
- (iii) non-parametric approach.

In the present survey we focus primarily on studies which have estimated productivity growth using the first approach. Wherever appropriate, the results from the estimation of cost and production functions have been mentioned in support of as alternative explanations to the results of the first approach. The non-parametric approach which is based on linear programming models of relative efficiency is not reviewed here.

Total factor productivity (TFP) extends the concept of single factor productivity such as output per unit labour or capital to more than one factor. Thus TFP is the ratio of gross output to a weighted combination of inputs. For the case of production function shown above, TFP at time t would be given by:

$$A_t = \frac{V_t}{g(K_t, L_t)} \quad (2)$$

where:

A_t: Index of TFP at time t.

g: the aggregation procedure implicit in the specific production function adopted.

Different functional forms of the production functions imply different aggregation procedures or weighting schemes for combining factor inputs. At this stage, choice exists in regards to the specification of output as value added (V) as in equation (1) above or gross value of output (Y). In the latter case, material and energy inputs are explicitly accounted for in both the left and the right hand sides in the production function. This would give rise to the following general functional form which in recent years has come to be known as KLEM type production function.

$$Y_t = g(K_t,\ L_t,\ E_t,\ M_t,\ t)$$

where:

Y_t = level of gross output per unit of time,
K_t = capital input (or service of factor capital)
L_t = labour input
E_t = input of energy,
M_t = material inputs.
t = time

The choice between one form of the other depends on what one believes to be the correct measure of output. It also depends on whether one believes the production function to be separable in factor and material inputs or not. The above functional forms give rise to alternative concepts of productivity. One can define the productivity measure associated with the value added (V) production function as total factor productivity (TFP) and that associated with gross output (Y) production function as total productivity (TP).

The observed growth in output is sought to be explained in terms of growth in factor inputs. The unexplained part or the residual is attributed to growth in productivity of factors. It consists in assuming a certain functional form for the producers' production function and then deriving an index number formula that is consistent (exact) with the assumed functional form. Preferred functional forms are the flexible ones. These indices differ from each other on the basis of underlying production function or the aggregation scheme assumed. Following are some of the most commonly used indexes.

Kendrick's index of total factor productivity for the case of value added as output, and two inputs can be written as

$$A_t = \frac{V_t}{(r_0 K_t + w_0 L_t)} \tag{3}$$

where:
A_t is the value of index in a given year,
V_t is the value of gross output,
w_0 and r_0 denote the factor rewards of labour and capital respectively in the base year.

The index measures average productivity of an arithmetic combination of labour and capital with base year period factor prices. It assumes a linear and a homogeneous production function of degree one. Besides constant returns to scale and neutral technical progress, it assumes an infinite elasticity of substitutability between labour and capital. The index can be generalised to allow for more than two factors. If a sufficiently long time series for this index can be constructed, then a trend rate of growth can be estimated econometrically. From the time series of Kendrick index yearly series (gt) can be formed by writing growth between successive years as

$$g^K_{t+1} = (A_{t+1} - A_t)/A_t$$

The growth rates thus obtained can be appropriately averaged for subperiods.

Solow's measure of productivity growth for two input case is given by (4)

$$g^S_{t+1} = \left[\frac{V_{t+1} - V_t}{V_t}\right] - \left[\frac{L_{t+1} - L_t}{L_t} + \frac{K_{t+1} - K_t}{K_t}\right]$$

where,
V_j = measure of output,

This measure is based on the general neo-classical production function. It assumes constant returns to scale, Hicks-neutral technical change, competitive equilibrium and factor rewards being determined by marginal products. Under these conditions, the growth of total factor productivity is the difference between the growth of value added and the rate of growth of total factor inputs. The latter is in the form of a Divisia index number i.e. a weighted combination of the growth rates, the weights being the respective shares.If we assumed specific Cobb-Douglas production function, with unit elasticity of output (unlike in the general functional form above) and took base year factor shares as weights, we would get Domar's geometric index of TFPG.

Assuming $A_1 = 1$, a time series of Solow index of productivity (A_t) can be formed from the formula:

$$A_{t+1} = A_t * (1 + g^S_{t+1})$$

Over forty years ago Malmquist (1953) proposed a quantity index for use in consumption analysis. The index scales consumption bundles up or down, in a radial fashion, to some arbitrarily selected indifference surface. In this context Malmquist's scaling factor turns out to be Shephard's (1953) input distance function, and Malmquist quantity indexes for pairs of consumption bundles can be constructed from ratios of corresponding pairs of input distance functions.1 Although it was developed in a consumer context, the Malmquist quantity index recently has enjoyed widespread use in a production context, in which multiple but cardinally measurable outputs replace scalar-valued but ordinally measurable utility. In producer analysis Malmquist indexes can be used to construct indexes of input, output or productivity, as ratios of input or output distance functions.

The period t output-oriented Malmquist productivity index is

$$M^t_0(x^t, y^t, x^{t+1}, y^{t+1}) = D^t_0(x^{t+1}, y^{t+1})/D^t_0(x^t, y^t).$$

$M_0^t(x^t, y^t, x^{t+1}, y^{t+1})$ compares $(x^{t+1}, y^{t+1})$to (x^t, y^t) by scaling y^{t+1} to Isoq $P^t(x^{t+1})$, that is, by using period t technology as a reference. Although $D_0^t(x^t, y^t) \leq 1$, it is possible that $D_0^t(x^t, y^t) > 1$, since period $t+1$ data may not be feasible with period t technology. Thus $M_0^t(x^t, y^t, x^{t+1}, y^{t+1}) \gtreqless 1$according as productivity change is positive, zero or negative between periods t and $t+1$, from the perspective of period t technology.

The period t output-oriented Malmquist productivity index decomposes as

$$M_0^t(x^t, y^t, x^{t+1}, y^{t+1}) = \Delta TE(x^t, y^t, x^{t+1}, y^{t+1}) * \Delta T^t(x^t, y^t, x^{t+1}, y^{t+1}) =$$

$$= \frac{D_0^{t+1}(x^{t+1}, y^{t+1})}{D_0^t(x^t, y^t)} \bullet \frac{D_0^t(x^{t+1}, y^{t+1})}{D_0^{t+1}(x^{t+1}, y^{t+1})},$$

where $\Delta TE(*)$ refers to technical efficiency change and $\Delta T^t(*)$ refers to technical change.

Translog measure of TFPG is given by:

$$g_{t+1}^T = \ln\left[\frac{Y_{t+1}}{Y_t}\right] - \left[\left[\frac{s_{t+1}^L + s_t^L}{2}\right] * \ln\left[\frac{L_{t+1}}{L_t}\right] + \left[\frac{s_{t+1}^K + s_t^K}{2}\right] * \ln\left[\frac{K_{t+1}}{K_t}\right]\right] \quad (5)$$

This expresses TFP as the difference between growth rate of output and weighted average of growth rates of labour and capital input. This is equivalent to Tornquist's discrete approximation to continuous Divisia index. The index is based on the translog function which describes the relationship between output and inputs and also between the aggregate and its components. The homogeneous translog functional form is flexible in the sense that it can provide a second order approximation to an arbitrary twice continuously differentiable linear homogeneous function. This functional form helps overcome the problem which arises with the Solow index where discrete set of data on prices and quantities need to be used in a continuous function. This index also imposes fewer a priori restrictions on the underlying production technology. The index can be generalised for more than two inputs.

Like in the previous case, from year to year changes in productivity growth one can construct a time series of the translog index as follows:

$$A_{t+1} = A_t * (1 + g_{t+1}^T)$$

Parametric approach consists in econometric estimation of production functions to infer contributions of different factors and of an autonomous increase in production over time, independent of inputs. This latter increase, which is a shift over time in the production function, can be more properly identified as technological progress. It is one of the factors underlying productivity growth. An alternative to estimation of production functions is estimation of cost functions using results from the duality theory. Below we give some commonly used specifications of production functions.

The general form of Cobb-Douglas Function has the following form:

$$V = A_0 e^t LK \tag{6}$$

where, V, L, K and t refer to value added, labour, capital and time. a and b give factor shares respectively for labour and capital. A_0 describes initial conditions. Technological change takes place at a constant rate l. It is assumed to be disembodied and Hicks-neutral, so that when there is a shift in the production function, K/L ratio remains unchanged at constant prices. In log-linear form this function can be written as

$$logV = a + \alpha logL + \beta logK + \lambda_t \tag{7}$$

The estimated value of l provides a measure of technological progress, which is often identified with total factor productivity growth.

The general form of Constant-Elasticity of Substitution Function has the following form:

$$V = A_0 e^t \left(L^{-\delta} + (1 - \lambda)K^{-\rho}\right)^{-\nu} \tag{8}$$

where l is the efficiency parameter, δ the distribution parameter, ρ the substitution parameter and u is the scale parameter. The elasticity of substitution $\sigma = 1/(1 + \rho)$ varies between 0 and μ. Technical change is Hicks neutral and disembodied. The value of λ (a measure of technical progress) can be estimated using a non-linear estimation procedure, or by using the following Taylor-series linear approximation to the CES function:

$$\ln V = \ln A_0 + \lambda t + \nu\delta \ln L + \nu(1 - \delta) \ln K - (1/2)\rho\nu\delta(1 - \delta)(\ln L - \ln K)^2 \tag{9}$$

This function can be estimated by OLS.

The general form of Transcendental Function has the following form:

$$\log V = \alpha_0 + \beta_L(\log L) + \beta_K(\log K) + \frac{1}{2}\beta_{LL}(\log L)^2 + \frac{1}{2}\beta_{KK}(\log K)^{2^2}$$

$$+\beta_{LK}(\log L)(\log K) + \beta_{Lt}(\log L)t + \beta_{Kt}(\log K)t + \frac{1}{2}\beta_{tt}t \quad (10)$$

where α's and β's are the parameters of the production function.

The rate of technical progress or total factor productivity growth is given by

$$\frac{\log V}{t} = \alpha_t + \beta_{tt}t + \beta_{Lt}(\log L) + \beta_{Kt}(\log K) \quad (11)$$

where:
α_t is the rate of autonomous total factor productivity growth.
β_{tt} is the rate of change of TFPG, and
β_{Lt}, β_{Kt} define the bias in TFPG.

If both β_{Lt} and β_{Kt} are zero, then the TFPG is Hicks-neutral type. If β_{Lt} is positive then the share of labour increases with time and there is labour using bias. Similarly, a positive β_{Kt} will show a capital using bias.

Due to results of the duality theory, one may estimate a cost function instead of production function to calculate technical progress. In its general form a four factor cost function can be written as

$$C = C(P_L, P_K, P_E, P_M, Q, t) \quad (12)$$

Specific forms of cost functions corresponding to each of the above functional forms can be derived. We give below the translog cost function which has many desirable properties sought out by researchers and which has been used most commonly in recent years.

The general form of Translog Function has the following form:

$$\log C = \beta_i + \sum_i \beta_i \log p_i + \frac{1}{2}\sum_i\sum_j \log p_i \log p_j + \beta_Q \log Q +$$

$$+\frac{1}{2}\beta_{QQ}(\log Q)^2 + \beta_{Qt}\log Q \log t + \beta_t \log t + \frac{1}{2}\beta_{tt}(\log t)^2 +$$

$$+\sum_i \beta_{Qi}\log Q \log p_j + \sum_i \beta_{ti}\log t \log p_i \quad (13)$$

Using Shepherd's lemma one can estimate demands for individual factors and shares in total cost of individual factors as follows:

$$\frac{\log C}{\log p_i} = \frac{x_i p_i}{C} = S_i = \beta_i + \sum_j \beta_{ij} \log p_j + \beta_{Qi} \log Q + \beta_{ti} \log t \qquad (14)$$

Rate of technical progress (λ_t) is given by

$$(t) = \frac{\log C}{t} = \frac{1}{t}\left(\beta_t + \beta_{tt} \log t + \beta_{Qt} \log Q + \sum_j \beta_{ti} \log p_i\right) \qquad (15)$$

Technical progress has a factor i using bias if $\beta_{ti} > 0$. It is neutral with respect to factor i if $\beta_{ti} = 0$ and it is factor i saving if β_{ti} is < 0.

4. Conclusions

Many studies have suggested that there is a close correlation between technological development and productivity (see for example Abramovitz, 1986; Fagerberg, 1987, 1988, 1994), and economists have analysed different possible views of why productivity growth has declined. These alternative explanations can be grouped into the following categories (Korres 1997):

- the capital factor, for instance investment may have been insufficient to sustain the level of productivity growth;
- the technology factor, for instance a decline in innovation might have affected productivity growth;
- the increased price of raw materials and energy;
- government regulations and demand policies that affect the productivity level;
- the skills and experience of the labour force may have deteriorated or workers may not work as hard as they used to;
- the products and services produced by the economy have become more diverse; and
- productivity levels differ greatly across industries.

The technological gap models represent two conflicting forces: innovation, which tends to increase productivity differences between countries; and diffusion, which tends to reduce them. In Schumpeterian theory, growth differences are seen as the combined result of these forces. We have applied an economic growth model based on Schumpeterian logic. This technological gap model provides a good explanation of the differences among various countries. The empirical estimates suggest that the convergence hypothesis applies for industrialised countries. Research on why growth rates differ has a long history that goes well beyond growth accounting exercises. The idea that poorer countries eventually catch up with richer ones was advanced as early as in the nineteenth century, to explain continental Europe's convergence with Britain. In the 1960s one of the most basic model was the Marx~Lewis model of abundant labour supplies, which explained the divergent growth experience of the Western European countries.

5. References

Abramovitz, M. (1986) 'Catching-up, foreign ahead and falling behind', Journal of Economic History, vol. 46.

Denison, E. F. (1962) *The sources of economic growth in the United States*, Washington: Committee for Economic Development.

Fabricant, S. (1954) *Economic progress and economic change* (Princeton, NJ: Princeton University Press).

Fageberg, J. (1987) 'A technology gap approach to why growth rates differ', Research Policy, vol. 16, pp. 87~99.

Fageberg, J. (1988) 'Why growth rates differ' in G. Dosi, C. Freeman, R. Nelson and L. Soete (ed) *Technical change and Economic Theory*.

Fageberg, J. (1991) 'Innovation, catching-up and growth' in *Technology and productivity - the Challenge for Economic Policy*, (Paris: OECD).

Fageberg, J. (1994) 'Technology and international differences in growth rates', Journal of Economic Literature, vol. XXXII, no. 3.

Fageberg, J. (1995) 'User-producer interaction, learning and comparative advantage', Cambridge Journal of Economics, vol. 19, pp. 243~56.

Griliches, Zvi (1973) 'Research expenditures and growth accounting' in B. R. Williams (ed.), *Science and technology in economic growth*, London.

Griliches, Zvi (1979) 'Issues in assessing the contribution of R&D to productivity growth', *Bell* Journal of Economics, vol. 10.

Griliches, Zvi (1980) 'R&D and the productivity slow down', American Economic Review, vol. 70, no. 2.

Griliches, Zvi and F. Lichtenberg (1984) 'R&D and productivity growth at the industry level: Is there still a relationship?', in Zvi Griliches (ed), *R&D, patents and productivity* Cambridge, Mass.: Harvard University Press.

Griliches, Zvi (1988) *Technology, education and productivity*, Oxford: Basil Blackwell.

Halter, A.N., H.O. Carter, and J.G. Hocking, "A Note on the Transcendental Production Function," Journal of Farm Economics (1957), 466-74.

Jorgenson, D. W., F. M. Gollop and B. M. Fraumeni (1987) 'Productivity and U.S. economic growth', *Growth in Aggregate Output* (Cambridge, Mass.: Harvard University Press).

Jorgenson, Dale W., (1988) "Productivity and Economic Growth," Washington Meeting of the Conference on Research and Income and Wealth, National Bureau of Economic Research, Cambridge, Mass.

Kendrick, J. W. (1984) *International comparisons of productivity and causes of the slowdown* (Cambridge, Mass.: Ballinger).

Kendrick, J. W. (1991) 'Total factor productivity - what it does not measure: an overview', in OECD, *Technology and productivity: the challenge for economic growth* pp. 149~57, (Paris: OECD).

Korres G. (1996) "Technical Change and Economic Growth: An Empirical Study for the European Member States" Avebury Press, London.

Korres G. (2009): "echnical Change and Economic Growth: Inside to the Knowledge Based Economy" Recent Evidence on European Perspectives, Avebury-Ashgate Publishing Company, London.

Maddison, Angus (1987), "Growth and Slowdown in Advanced Capitalist Economies," The Journal of Economic Literature, 25 (1987) 649-698.

OECD: (2000): *Economic Outlook,* No: 68, Paris, France.

OECD: (2001): Economics Department Working Paper No. 248, (Scarpetta et al) May 2001.

OECD, STAN and National Accounts databases, May 2001.

Schmookler, J. (1966) *Invention and economic growth* (Cambridge, Mass.: Harvard University Press).

Schumpeter, J. A. (1934) *The theory of economic development* (Cambridge, Mass.: Harvard Economic Studies).

Schumpeter, J. A. (1942) *Capitalism, socialism and democracy* (New York: Harper).

Solow, R. M. (1957) 'Technical change and the aggregate production function' Review of Economics and Statistics, vol. 39, pp. 312~20.

Terleckyj, Nestor E. (1974), Effects of R&D on the Productivity Growth of Industries: an Exploratory Study, Report No. 140 (Washington DC: National Planning Association, 1974).

—— (1980), "What Do R&D Numbers Tell Us About Technical Change?" American Economic Review Papers and Proceedings, 70 (1980), 55-61.

—— (1983), "R&D as a Source of Growth of Productivity and of Income," in Franke, R.H. and Associates, editor, The Science of Productivity, (San Francisco: Jossey-Bass, 1983).

—— (1984), "R&D and Productivity Growth at the Industry Level: Is There Still a Relationship: Comment," in Zvi Griliches, editor, R7D, Patents and Productivity (Chicago: The University of Chicago Press for the National Bureau of Economic Research, 1984), 496-502.

Notes for Contributors

Correspondence and Inquiries

All correspondence and inquiries regarding reprints, manuscript preparation, or the status of manuscripts should be directed to the Editor.

Subscription Rates

For subscriptions please contact the Editor.

Aims and Scope: The Southeuropean Review of Business Finance & Accounting publishes original research articles of theoretical, empirical, and experimental work on all aspects of business finance and accounting and other interdisciplinary to these areas subjects. Accepted language is English. For practical reasons, papers submitted for publication should not exceed the number of 30, single space pages, all material included.

Editorial Policy: *The Southeuropean Review of Business Finance & Accounting* is committed to the principle of double-blind review and prompt turnaround on the manuscripts it receives on the basis of the stated aims of the Journal. A new submission will generally not require more than four months total time with the Journal. For the large majority of manuscripts the Journal will make an accept-reject decision on the first round provided that authors will promptly revise accepted manuscripts in order to accommodate reviewer and editor comments of minor scale. An editorial revise and resubmit decision is reserved for submissions which are not acceptable in their current version but the indicated changes can make the manuscript publishable.

Correspondence address: Submissions (with cover letter) should be sent by email to: sreview@in.teipir.gr.

Alternatively a 3.5” floppy disk with the operating system and word processing program along with the author name(s) and manuscript title written on the label can be sent to:

Dr. Constantine Cantzos
Department of Accounting
The Technological Education
Institute of Piraeus
250 Thivon Avenue,
122 44 Egaleo
Athens, Greece

Manuscript Preparation: Submission of manuscripts (including notes, references, tables, and legends) should be typed double spaced on 8.5” × 11” (21 cm × 29,7 cm) white paper with 1” (2.5 cm) margins on all sides. Sections should appear in the following order: first page with title names and abstract, following right after with main text, appendices, acknowledgments, notes, references, tables, figure legends, and figures.

First Page: The first page should show on top the article title and underneath, in left side, the author name(s) and affiliation, with e-mail address, telephone number, and the address where the page proofs and reprints should be sent and other correspondence addressed.

Abstract: An abstract of no more than 100 words and double-spaced should follow on same page right after title and names and before the main text.

JEL Classification: Authors should indicate in the appropriate place in the 1st page of the article its corresponding Journal of Economic literature classification code which can be found in the site *www.aeaweb.org/journal /jel_class_system.html*

Keywords: A maximum of three keywords, not included in the title of the article, should appear right after the abstract.

Main text: The introduction should have no heading or number Subsequent headings (including appendices) should be designated by arabic numerals (1, 2, etc.) and subsection headings should be numbered 1.1, 1.2, etc. Figures, tables, and displayed equations should be numbered consecutively throughout the text (1, 2 etc.). Equation numbers should appear flush right in parentheses.

Appendices: Appendices should appear as a separate section after the text and before references.

Acknowledgments: Any acknowledgments should appear as a separate section after the text and appendices and before notes.

Notes: Notes should be numbered consecutively and designated by superscripts (^{1}, ^{2}, etc.) in the text. All notes should be typed double – spaced beginning on a separate page following the text and acknowledgments, and before the references.

References: An alphabetical reference list, whose content and format conforms to the examples bellow, should appear at the end noting that:

secondary lines are indented; author's names are given in full; page numbers are required for articles in readers, journals and magazines; where relevant, translator and date of first publication of a book, and original date of reprinted article, are noted. Journal and book titles should be italicized. References with up to three authors should include the names of each author, while references with four of more authors should cite the first author and add "et al.". It is the responsibility of the authors to verify all references. Each author should be listed in chronological sequence.

Example:

Book

Cambell D. and Stanley J. (1966), *Experimental and Quasi-Experimental Designs for Research,* Rand McNally and Company, Chicago.

Article in edited volume

Casberg B. V. (1984), "The Usefulness of Current Cost Accounting: Report on a Research Programme", in *Current Cost Accounting: The Benefits and the Costs,* Casberg B. V and Page M. (eds.), Prentice-Hall International in association with the Institute of Chartered Accountants in England and Wales, London, V.I., p.2.

Article in Journal

Chua W.F. (1996a), "Theoretical Constructions of and by the Real" *Accounting Organizations and Society,* 11 (6): 586.

Article in newspaper

The New York Times (1998), "The money show", 25 July 1998:9.

Unpublished

Myers A. (2000), "The day of the week effect phenomenon in the Athens Stock Exchange", Ph. D dissertation, Department of Finance and Accounting, University of Liverpool.

More than one work of same author, following his first, appears with a line in the place of the author's name.

Tables: Tables should be numbered and titled, and typed double-spaced, each on a separate sheet, following the references. Notes to tables should be designated by superscripted letters (^{a}, ^{b}, etc.) within each table and typed double-spaced on the same page as the table. Use descriptive labels rather than computer acronyms, and explain all abbreviations. When tables are typed on oversized paper, please submit both the original and a reduced copy.

Figures: Figure legends should be numbered and typed double-spaced on a separate sheet following the tables. Figures for accepted manuscripts should be submitted in camera-ready form, i.e., clear glossy prints or drawn in India ink on drafting paper or high quality white paper. Lettering in figures should be large enough to be legible after half-size reduction. Authors should submit one 5” × 7” (13 cm × 18 cm) original and two photocopies of each figure, with authors’ names, manuscript title, and figure number on the back of each original and copy (use gummed labels if necessary to avoid damaging originals). Figures should be enclosed in a separate envelope backed by cardboard and without staples or paper clips.

Page Proofs and Reprints: Corrected page proofs must be returned within three days of receipt, and alterations other than corrections may be charged to the authors. Authors will receive 20 free reprints, and may order additional copies when returning the corrected proofs.